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ON THE RESISTANCE OF BONITO FISHING BOATS.

By

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Introductory :—

The fishing area of our country covers many thousand square miles both along the coast and out on the ocean, and the weather conditions are not always favourable. It is not uncommon to find, in certain districts, particular shapes of fishing boats adopted for these particular districts.

Recently, owing to the shifting of fishing grounds far out off the coast, the size of hull became larger to ensure the necessary seaworthiness and naturally the engine is increased in its power. There seems, however, some so called local shapes which are often maintained for new boats even under the above condition, probably due to the reason, that each inherent shape has its own merits for particular fishing route, wind, wave and harbour conditions, etc.

But actually nowadays, fishing boats from quite different districts engage in the same kind of fishing at nearly same place out on the ocean, therefore the practice of maintaining a local colour on boat shape becomes somewhat unimportant.

Such being the case, the present day necessity is to design a boat not strictly after the old form but with some modifications to meet the general requirements of a fishing boat, and in doing so, there are quite many things to be taken into a consideration. The resistance of hull, for instance, is one of the important items to be investigated.

In our Institute, the first step for the investigation was the testing of the boat-shape in still water to determine its resistance through the water.

It is clear, of course, that the resistance is not the only item to determine the shape. There are quite many other items to be considered, for instance, stability, general arrangement, propelling machinery, capacity of hold, etc. But, if proper judgment from the stand point of resistance is given to a new design, there will be certainly a gain which is not insignificant, considering the enormous number of power-driven fishing boats in our country.

Types Tested :—

The boats tested first were Bonito fishing boats and the following results were obtained. Owing to the limited fund, only five were selected which were sent up from the fishing districts of WAKAYAMA, MIYE, MIYAGI, KAGOSHIMA and NAGASAKI Prefectures. The selection was made not because they are the representative types of the districts concerned, but because their particulars and data are fairly complete, moreover their characteristic differences are so noticeable that their comparative merits would appear significantly in the testing results. Their particulars and lines are shown in the Table 1. and Fig. 1.—5.

Table 1.

	Length	Breadth	Depth	Gross Ton.	Brake Horse Power	Speed, knots	Draft Fore	Draft Aft	
MIYAGI	53′-0″	12′-0″	5′-4″	18.42	40	8	——	——	Pure European type, no knuckle, narrow keel.
NAGASAKI	50′-0″	10′-0″	5′-0″	17.00	25	9	——	——	Mixed type, knuckle at midship, wide keel. Large dead flat at stern.
MIYE	53′-0″	11′-0″	5′-6″	19.50	25	8	2′	4′	Almost European type, very short knuckle at midship, wide keel.
KAGOSHIMA	68.4′	14.6′	7.7′	——	——	——	——	——	Japanese type, knuckle all through, wide keel.
WAKAYAMA	54′-0″	11′-0″	5′-6″	17.00	25	8	——	——	Mixed type, knuckle at midship, wide keel.

Preparations for Experiments and Method of Testing :—

Lines to the outside of hull were prepared with square stations, water lines, etc., conveniently arranged for model making and also for various calculation purposes. Models were made of wood, about five feet in length, and were adjusted to the required drafts with necessary ballasts. They were towed at different drafts in the experimental tank in our Institute and the towing speeds and the corresponding total resistances were recorded. The adjustment of drafts was made by changing the ballast and various speeds were obtained by properly manoeuvering towing device. The resistance was recorded on the towing dynamometer and the speed was measured by the time required to run a certain known distance. Experimental apparatus will be explained later.

Record of Experiments Plotted :—

Fig. 6.—10. show the total resistances for the five ships at various speeds and also for two different drafts. The curves for the frictional resistance were calculated by using the results obtained by towing a plate having the length equal to that of the model and coated with the same paint as used on the model.

Fig. 7.
NAGASAKI.

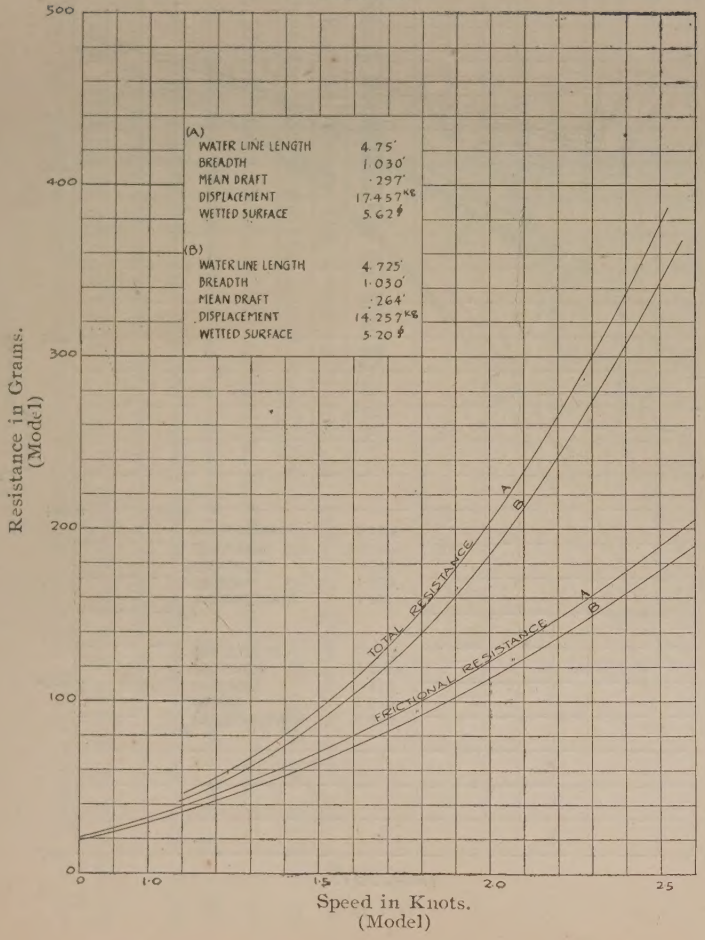


Fig. 6.
MIYAGI.

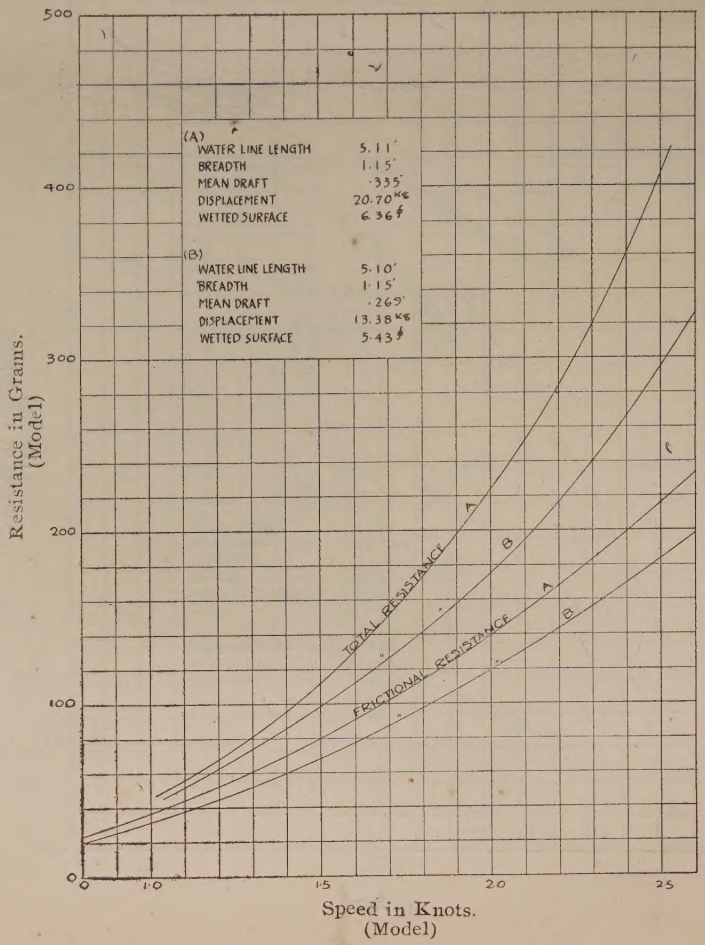


Fig. 8.

MIYE

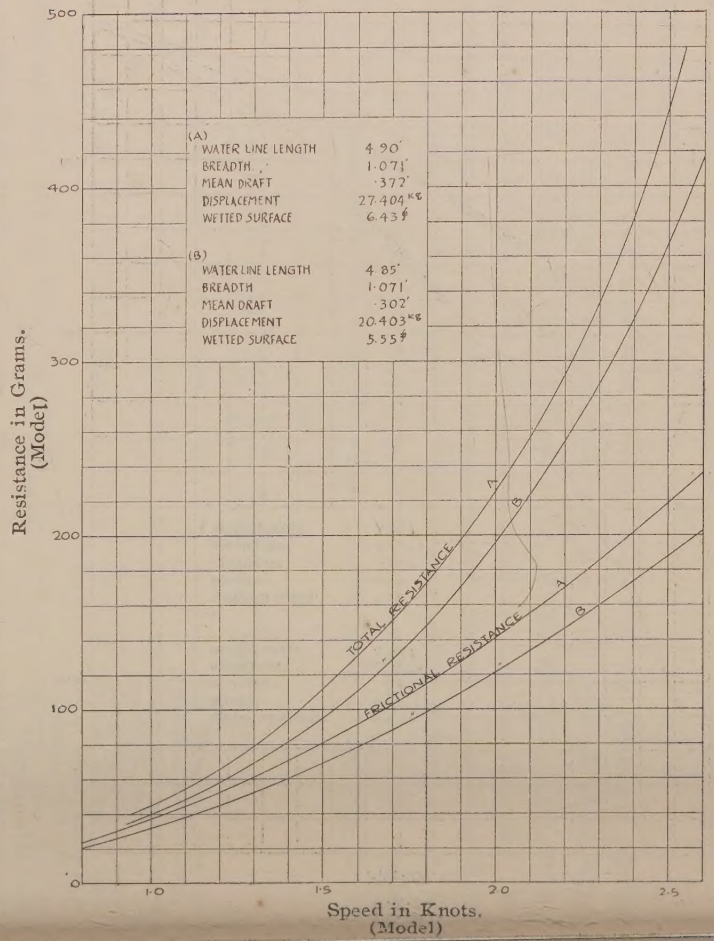


Fig. 9.

KAGOSHIMA

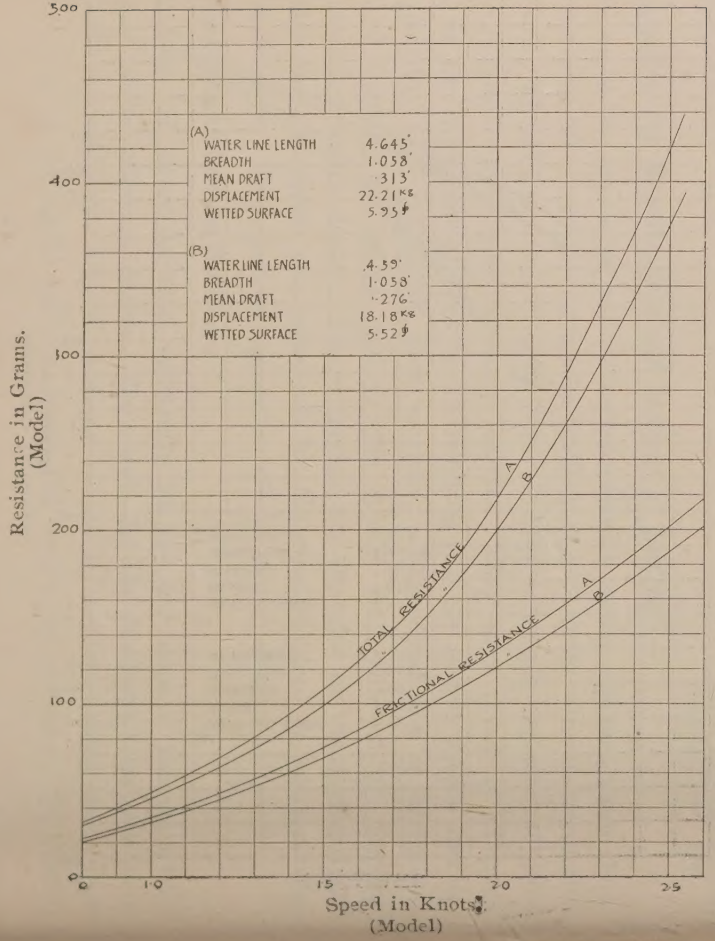
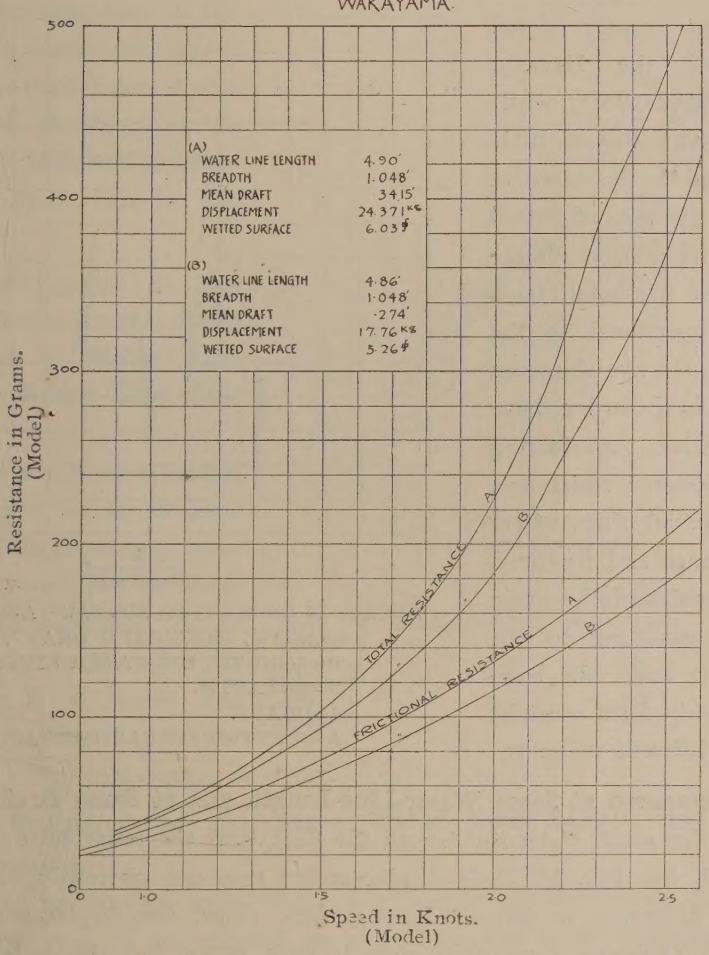


Fig. 10.



General Consideration on the Results :—

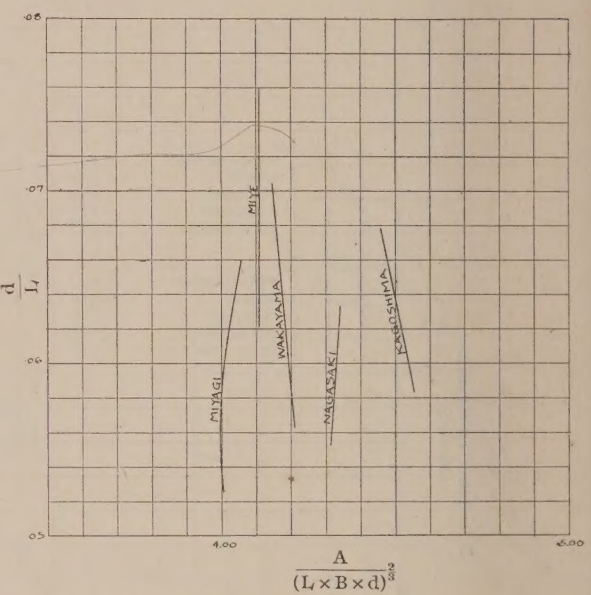
Fig. 11. shows the wave resistance or residuary resistance per ton of displacement plotted on the speed length ratio, $V/\sqrt{L}$. Referring to the curves, the MIYE shows small value, while the NAGASAKI and the WAKAYYMA seem to be inferior. Some appear to be favourable at low speed, but not at high speed. The reason that the MIYAGI model shows high value at very low speed may be accounted for its small displacement in shallow draft.

The relation of wetted surface area to the general size of hull is best shown in Fig. 12, where wetted su-face area divided by $(L \times B \times d)^{\frac{2}{3}}$ is plotted on the

base of draft/length. The curves show nearly equal character for the MIYAGI, MIYE and WAKAYAMA, while the NAGASAKI has a little more area and the KAGOSHIMA has an excessive area of wetted surface for its general dimension. As the frictional resistance is proportional to the wetted area, the five ships can be arranged in the order above described when considering only the frictional resistance.

In an actual ship, where wave resistance and frictional resistance combine in a certain proportion according to the type and the draft, the comparison of ship form must be made in a different manner.

Fig. 12.



RELATION OF WETTED SURFACE AREA TO LENGTH, BREADTH & DRAFT.
L=LENGTH, ON WATER LINE.
B=BREADTH.
d=DRAFT.
A=WETTED SURFACE AREA.

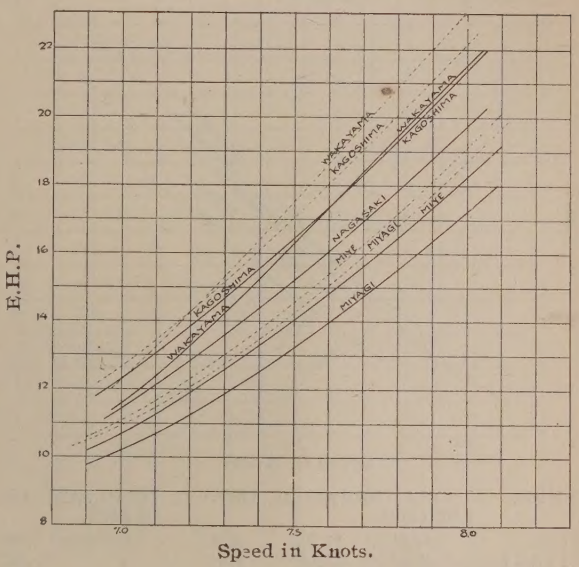
E. H. P. Compared at Same Warer-Line-Length and at Same Draft.

When the same water-line-length (54 Feet) and the same draft (3.36 Feet) are assumed, (see Fig. 13) their displacements may not obviously be the same due to the difference in forms. Among these ships, the displacements of the MIYE and WAKAYAMA come quite close to each other, but the latter requires much higher E. H. P. in the speed range used, obviously depending on greater wave resistance in the case of the WAKAYAMA, (see full line in Fig. 13.). It seems that the trim of the ship is not favourable. The NAGASAKI shows high E.H.P. even for smaller displacement. The KAGOSHIMA and MIYAGI were not compared with, as there are too much difference in displacement. The comparison conducted on a little deeper draft (3.53 Feet) shows (see dotted line in the Fig.) nearly the same results (excluding the NAGASAKI, which was not tested at such a deep draft).

A point to be noticed is that E.H.P. for the MIYAGI increases with the

increase of displacement at much higher rate than in the case of the MIYE. Therefore, when the MIYAGI takes nearly the same displacement as the MIYE, its E.H.P. will probably be more than that of the MIYE.

Fig. 13.



E. H. P. Compared at the same Displacement, Ratio of Draft to Water Line Length Being Kept Constant.

Every model is expanded or contracted so as to have the same displacement, keeping the ratio of draft to water line length constant. As in the Fig. 14, the MIYE has the lowest E. H. P. curve and MIYAGI, KAGOSHIMA, NAGASAKI and WAKAYAMA come in order.

TYPE.	W.L. LENGTH.	BREADTH.	(E.H.P. IN FULL LINE) DRAFT.	DISPT.	(E.H.P. IN DOTTEDLINE) DRAFT.	DISPT.
WAKAYAMA	54.0′	11.60′	3.36′	27.55 TONS	3.53′	29.30 TONS
KAGOSHIMA	〃	12.40′	〃	30.70 〃	〃	32.80 〃
NAGASAKI	〃	11.68′	〃	24.95 〃		
MIYE	〃	11.95′	〃	27.80 〃	〃	29.75 〃
MIYAGI	〃	12.15′	〃	21.85 〃	〃	23.90 〃

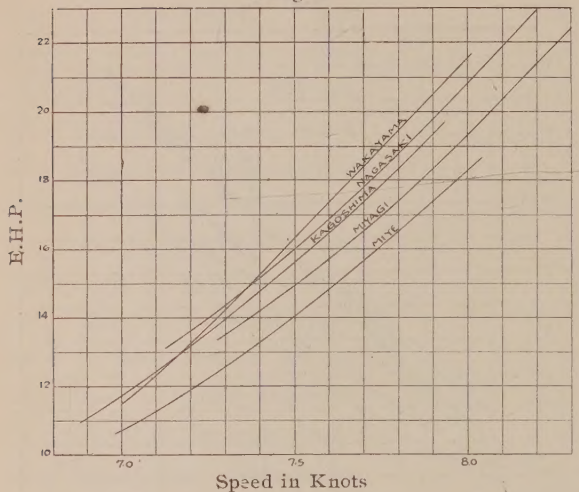
E. H. P. Compared for the Same Water Line Length and the Same Displacement.

For the five models same water line length (54 Feet) were assumed, and their drafts were to be adjusted so as to have the same displacement. But, some difficulties prevented the experiments in deeper draft for the NAGASAKI and MIYAGI. The other three, therefore, were made to have the same displacement (27.8 tons, see Fig. 15, and 32.0 tons, see Fig. 16.). In both cases, the MIYE is the best. The NAGASAKI and MIYAGI were adjusted to have the same displacement of 24.0 tons (see Fig. 15.). As they show higher value of E. H. P. notwithstanding their displacement is less than the above three, they seem to be inferior.

General Conclusions :—

Generally concluding from the above comparison, it seems clear that the

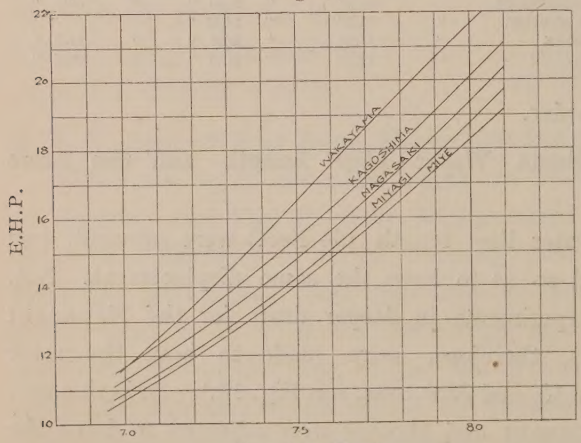
Fig. 14.



Speed in Knots

TYPE.	W.L. LENGTH.	BREADTH.	DRAFT.	DISPLACEMENT.	Cb.
MIYE	54.0′	11.95′	3.36′	27.80 TONS	.449
MIYAGI	58.5′	13.16′	3.64′	〃	.347
KAGOSHIMA	52.3′	12.00′	3.26′	〃	.477
NAGASAKI	56.0′	12.10′	3.48′	〃	.413
WAKAYAMA	54.2′	11.64′	3.37′	〃	.458

Fig. 15.



Speed in Knots.

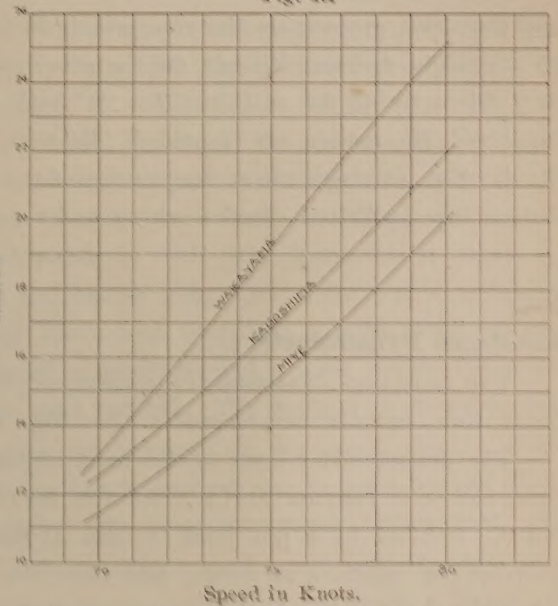
TYPE.	W. L. LENGTH.	BREADTH.	DRAFT.	DISPLACEMENT.
MIYE	54.0′	11 95′	3.36′	27.80 TONS
KAGOSHIMA	〃	12.40′	3.16′	〃
WAKAYAMA	〃	11.60′	3.39′	〃
MIYAGI	〃	12.15′	3.54′	24.00 TONS (MAX. DISPT. TESTED)
NAGASAKI	〃	11.68′	3.30′	24.00 TONS

form of the MIYE is the best, KAGOSHIMA and WAKAYAMA the worst.

Some considerations about the particular form and its influence on the resistance are interesting. As shown in the lines, the KAGOSHIMA has knuckle lines all fore and aft. One at the fore body along the bilge seems to be not important, as it generally appears not to have too much inclination to the free flow of water, but one at the aft body along the bilge looks to be detrimental, as it nearly crosses the free flow of water. Besides the above, such a form has greater wetted area compared to the forms with ordinary fair smooth sections. The results lead to an unfavourable shape, especially when used for fishing boat where the speed length ratio is pretty high. The NAGASAKI has not much speciality both fore and aft, but at the stern water lines not ending fair to the stern post, but meeting with the dead wood with an appreciable angle, makes a discontinuous flow. The WAKA-

YAMA has a good line both fore and aft, but due to its trim and rather wide keel, there seems to occur some resistance which will be brought in as in the case when a plate pushed ahead making a small angle with stream. The point however requires further investigations and experiments. The MIYAGI and MIYE have good fair lines both fore and aft and it is difficult to find much difference between the two, but minute investigation discloses that the MIYAGI has a little fuller water line at the bow. It is a well known fact that the resistance is always greater when the water lines at fore body are full somewhere near the load water line. The reason that the MIYAGI has the high E.H.P. is probably due to the fact above mentioned. The MIYE has not practically any such source of trouble from the point of view of resistance.

Fig. 16.



TYPE.	W. L. LENGTH.	BREADTH.	DRAFT.	DISPLACEMENT.
MIYE	54.0'	11.95'	3.75'	32.00 TONS
KAGOSHIMA	〃	12.40'	3.48'	〃
WAKAYAMA	〃	11.60'	3.77'	〃

General Arrangement of the Apparatus for the Experiments:—

The experimental tank and the apparatus in the Fisheries Institute were nearly completed at the end of August, 1923, and the preparations for testing run were arranged at that time. The great earthquake and the fire following, however, completely destroyed the whole establishment, including tank house, accessories, model cutting machine, etc., leaving the water basin only. The apparatus now installed and used for the experiments (see Fig. 17, General View) is only for the temporary use until the original design is restored.

There are two straight ways more than 100 feet long, properly supported and set parallel to each other and to the water surface. Its distance between centre to centre is 24 inches. A small carriage of aluminium with 4 wheels

runs on the rails. The wheel shafts have ball bearings and two wheels on the one side have grooves on the rim, which fit to the rail, and guide the carriage on a straight course. Wheels on the other side have the rims planed, so that they ride only on the rail surface. At both ends of the rails grooved wheels supported frictionless are provided. Between these an endless wire rope is fitted. The carriage above described is fixed to the wire rope. To drive the endless rope, a Pelton wheel working under constant water head is designed and its shaft is connected with that of grooved wheel by means of a reversing gear.

Resistance Dynamometer :—

The resistance dynamometer consists of a dynamometer lever, a recording drum, time and distance recorders. (See Fig. 18 and Fig. 19.).

The dynamometer lever is the most important part. Its general form is a cross bar with fulcrum at (A). At the lower part of the cross bar a towing rod (C) is fitted by a pin joint (B) and at the upper end a forked part (H) is provided, on which a recording pen rod (I) is placed. In the instrument constructed, the length (A)-(H) is made as long as five times as that of (A)-(B), the movement of (H) is, therefore, 5 times that of (B). The towing rod (C) has a sharp point (E) at the end of curved part (F). The point (E) is lightly pressed into a coned hole (D) which is made on a piece fixed to the model. The rod itself is balanced at (B) by an adjustable counterweight (G). The resistance recording pen rod (I) is also balanced about the forked end (H) by an adjustable counterweight (J), and a pen (K) at the end of rod lightly touches on the smoked paper wound around the recording drum (L). The whole system is adjusted by the weight (M) to have the centre of gravity slightly below the fulcrum (A) to take vertical position when at rest.

Before conducting the towing run, a weight (N) properly judged to be nearly equal to the force of resistance is hanged at an arm of horizontal lever (O) to act in the direction to balance the resistance. Whole arrangement is checked so that the lever becomes vertical when the resistance balances with the weight. As the weight (N) is determined merely by judgment there must be some difference, and to measure the amount a spring device is provided. (P) is a spring which at the one end hangs on a point (Q) on the vertical lever and at the other end on a traverser (R). The traverser (R) has a nut (S) on its one side and grooved feet (T) on the other. (S) can be shifted by means of thumb

wheel (U) and threaded shaft (V), and grooved feet (T) are guided on a rail (Y). Also (S) has two pointers, one (W) to indicate its position on a corresponding scale close by, the other (X) properly supported and extended over the drum, to record the base line for the spring. A weight (Z) is hanged at a point on the horizontal arm to give necessary initial tension to the spring. By the above construction, when the horizontal towing resistance at (B) or (E) exceeds the weight (N), the vertical lever tends to incline to extend the spring, the amount of extension corresponding to the excess.

At the beginning and also at the end of experiments, the whole system is taken out of the carriage referred above and placed on a solid plane surface. Properly selected spring (P) is placed in position, and a light weight (Z) is put on the horizontal arm to make the lever vertical. The position of recording pen and of spring base line at that time are marked on the paper. Next, at (E) an accurately measured horizontal tension is applied and an equal weight (N) is hanged at (O) and we check whether the lever is vertical. After that, the horizontal tension at (E) is increased sucessively by a small amount and corresponding shifted position of recording pen is marked on the paper. These are to be used for the scale to read the actual record taken while towing the model. Base line positions are kept for reference with the spring No. used.

The fulcrum (A) of the vertical lever is required to be made most accurately. Not only the weight of the cross bar is to be supported at the fulcrum but also free swinging of the lever about the point must be allowed, while transmitting the towing force. The shaft or spindle (see Fig. 20) of hardened steel is about 2½ in long. The middle part (d) where cross bar is fixed and the both ends (e) and (f) are cylindrical in shape, but the intermediate parts are sharp sectors as shown on the drawing. The apex of sector coincides with the centre line of spindle and forms a knife edge. The groove (O) to receive the knife edge consists of two pieces. The one has a plane surface (gg, hh), the other a plane (ii, jj), and when the both are placed side by side the edges (gg and ii) meet and form an angular groove (O). The bottom thus formed is used for receiving the knife edge and the shape of the sector above mentioned is constructed to suite the groove. To prevent the spindle flying out of the groove, an inclined slot is cut on the end face of (e) and (f), into which a pin is loosely inserted sideway. The pin does not touch to the slot when towing, but when the knife edge tends to go out of the groove the pin touches to the slot, thus preventing

the flying out of the knife edge.

Recording drum is a drum on which sheet of paper is wound. The drum is geared to make one complete turn while the carriage covers the whole length of rail. The drive is taken from one of the shafts of wheels, using gear coupling, worm gearing and rope pulleys. Distance recorder is a pen worked by a magnet which is in a circuit with battery and contact maker in series. The contact maker is arranged to close the circuit at given interval of distance when the carriage goes along the rail.

Time recorder is also a pen worked by another magnet which is in a circuit with battery and chronograph in series.

The whole apparatus is arranged on a table in the carriage and can be raised or lowered according to the water level or different draft of model.

Carriage and Rails :—

The carriage is a rectangular frame work of aluminium angle bars and channel bars (see Fig. 21 and 22). Besides the necessary strengthening members it has at its middle part a supporting frame for dynamometer and at the both ends, the supports or brackets for guide bars etc. Inside the supporting frame for dynamometer is a frame work (2) with four nuts (3) at corners, which engage the vertical threaded shaft (1). By turning the thumb wheel (4) on the top of shaft (1), the frame work (2) can be raised or lowered. The dynamometer previously described is placed on this frame work (2) and fixed by a suitable method.

The guide bars are of circular rods, one at the bow and the other at the stern of model ; each is fixed to the support or bracket (6) by a screw (7) to be held in a definite position. Lower end of the bar is inserted into a slot cut in a metal sheet fixed to the model. Thus the straight course of model is maintained while being towed.

Near the corners of carriage, four wheels (9), (10), (11) and (12) are fitted on the shafts with ball bearings. Two wheels on one side have grooves to fit the rail surface, but the wheels on the other have a plain rim and only ride on the rail surface.

A gear coupling (13) and worm gearing (14) are provided between one of the wheels (12) and rope pulley (16). The pulley (16) turns the recording drum by a rope belt. Speed ratios of the intervening gears are so designed as to make the recording drum to turn one complete revolution while the carriage

travels the whole length of the rail.

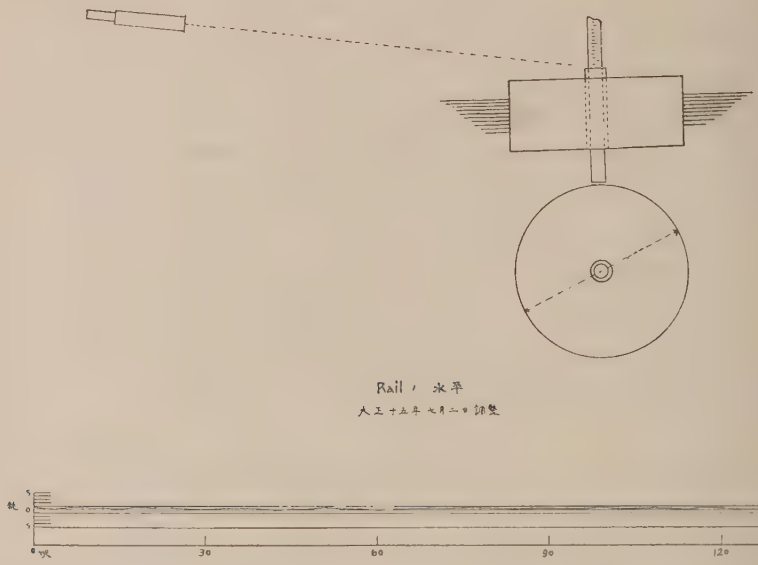
To damp the fore and aft oscillation of model, vessels (17) full of thick oil are placed on the bow and stern of model, and the dampers (18) are fitted to the guide bars (15) by means of a rod (19). Also a lever is loosely fitted to the guide bar at the stern. The lever holds the model while accelerating and is automatically released when nearly uniform speed is attained. The same arrangement is provided at bow to hold the model before retardation occurs.

About the rails and their adjusting device, many angle bars are fixed transversely across the top of tank walls, at about 6 feet spacing. At the under surface of the angle bars, other two angle bars are fitted to support the rails parallel to the centre line of tank. In Fig. 23, (A) shows the girder on one side. The rail is made of a brass pipe, $\frac{3}{4}$ inch in diameter, 16 feet long and scarphed at its ends to make a long line. The sleeper (C) is a short lug piece and has three bolts on the top flange. The one at the centre is firmly fixed to the girder and passes through the slot on the sleeper (C), and by turning the nut (E) the horizontal flange of the sleeper (C) is drawn closer to the girder, while by turning the bolts (F) and (G) distance between the sleeper and girder is checked. Thus the up and down position of the sleeper is properly adjusted. About the vertical flange, also, the same principle is applied, i.e. two bolts (H) and (J) draw the sleeper nearer to the girder, while the bolts (K), (L), (M) and (N) check the distance between sleeper and girder.

The pipe forming the rail is placed to the bolt (O) which is firmly fixed to the sleeper. It is tightened up by lock nut (R) using two curved washers (P) and (Q). To minimize the shock at the rail joint, it is scarphed (see Fig. 23) and the core at the joint is fixed to the pipe end on one side and loosely fitted to the other. The hole in the core for the fixing bolt or pin is elliptic, thus allowing axial motion.

To check the straightness of the rails, a gauge properly constructed is placed on the rail and its height is observed by a telescope and is adjusted by those bolts already mentioned. For checking the level a float with pointer and hole at the centre is placed on the water surface and a rod with scale is inserted into the hole of the float (see Fig. 24). The upper end of the rod is fixed to a point on the carriage and the position of the float is read on the scale by using telescope. The annexed curve is a record of observation after the adjustment of level. The effective run is of course taken at the part comparatively horizontal,

Fig. 24



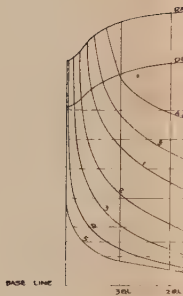
where the maximum level difference is less than $\frac{1}{2}$ mm. The check and adjusting of the level have been conducted at intervals and we found no much difference.

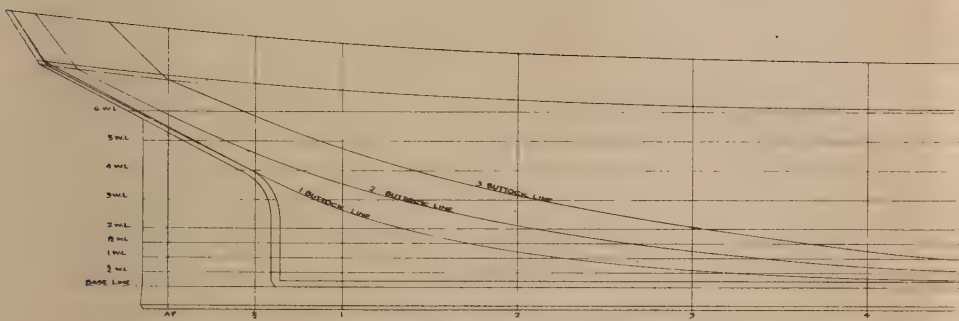
Towing Arrangement :—

A cylindrical steel water reservoir of ample capacity is placed on a steel framed tower near the experimental tank (Fig. 17). A centrifugal pump (B) driven by a 5 H.P. three phase induction motor (A) pumps the water from the tank to the water reservoir by a suction pipe (C) (Fig. 25 and 26). Overflow over the margin of the reservoir is led back to the tank by a small pipe (D). Thus the water level in the reservoir is kept constant and about 24 feet above the level of tank water. A pipe with sluice valve is led from the reservoir to the Pelton wheel (G). Its tail race is led into tank. By proper adjustment of sluice and nozzles (E) and (F) the wheel shaft makes a predetermined number of revolution. Proper bulkhead is fitted in the tank to prevent the disturbance of water to be transmitted to the main part of experimental tank. To the shaft of Pelton wheel, a light belt is fitted to turn the tachometer (H), giving the guide to the manoeuvering of sluice and nozzles. Main belt from the shaft passes to the reversing gear (K) and thence to the grooved wheel (L) on which endless wire-rope is wound. Two grooved wheels, one at the fore end of the rail, the other at the aft are of nearly the same construction, but the former has a belt pulley

(M) and a handle (N) (see Fig. 27). By turning the handle (N), the wheel (L) slides bodily along the surface on the bed plate, thus giving suitable tension to the endless belt of wire rope.

All the experimental apparatas were planned after our own design and manufactured in our work shop except motor, pump, and other castings of large size.


BASE LINE


6 W.L
5 W.L
4 W.L
3 W.L
2 W.L
1 W.L
½ W.L
BASE LINE
1 BUTTOCK LINE
2 BUTTOCK LINE
3 BUTTOCK LINE
AP
½
1
2
3
4

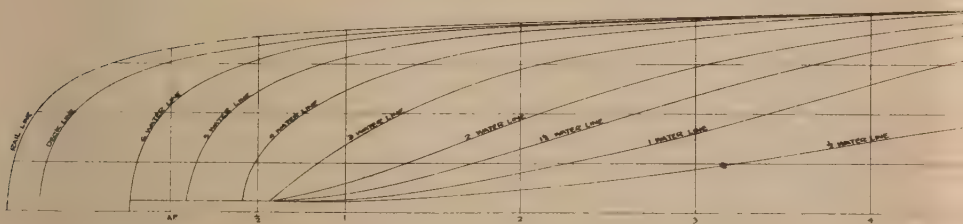
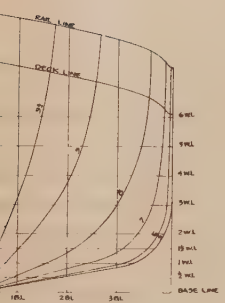
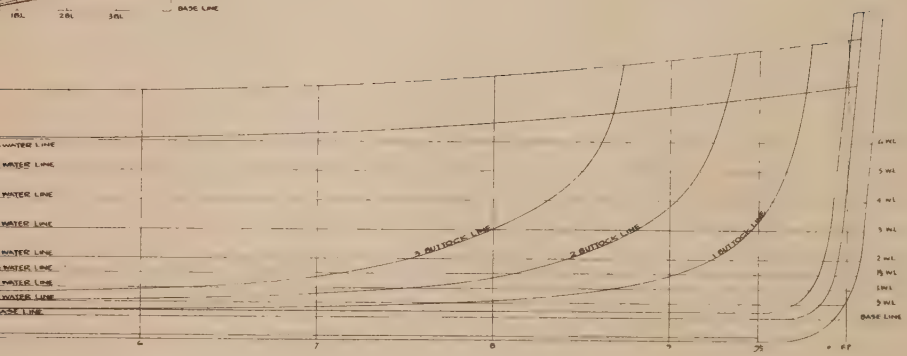
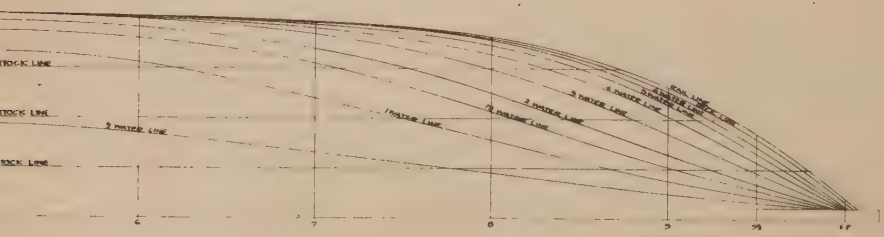

DECK LINE
SHEER LINE
4 WATER LINE
3 WATER LINE
2 WATER LINE
1 WATER LINE
½ WATER LINE
2 WATER LINE
1½ WATER LINE
1 WATER LINE
½ WATER LINE
AP
½
1
2
3
4

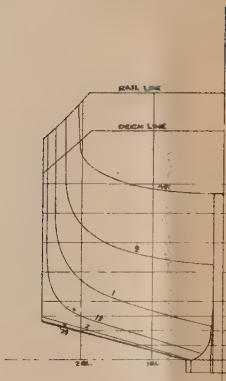
Fig. 1.

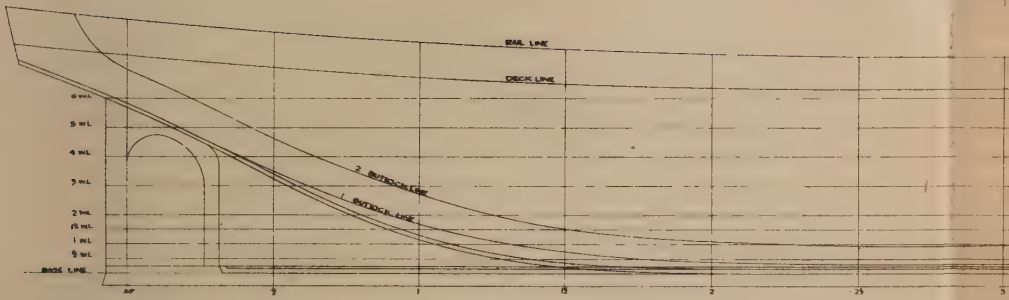
MIYAGI


RAIL LINE
DECK LINE
6 WL
5 WL
4 WL
3 WL
2 WL
1½ WL
1 WL
½ WL
BASE LINE
1BL
2BL
3BL


WATER LINE
WATER LINE
WATER LINE
WATER LINE
WATER LINE
WATER LINE
WATER LINE
WATER LINE
ASE LINE
3 BUTTOCK LINE
2 BUTTOCK LINE
1 BUTTOCK LINE
6 WL
5 WL
4 WL
3 WL
2 WL
1½ WL
1 WL
½ WL
BASE LINE
6
7
8
9
9½
0 FP


TOCK LINE
TOCK LINE
TOCK LINE
9 WATER LINE
1 WATER LINE
3 WATER LINE
5 WATER LINE
6 WATER LINE
6
7
8
9
9½
FP


RAIL LINE
DECK LINE


RAIL LINE
DECK LINE
6 W.L.
5 W.L.
4 W.L.
3 W.L.
2 W.L.
1½ W.L.
1 W.L.
½ W.L.
BASE LINE
2 BUTTOCK LINE
1 BUTTOCK LINE
AP
½
1
1½
2
2½
3

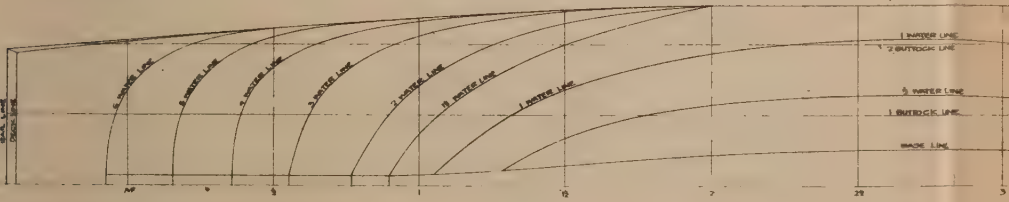
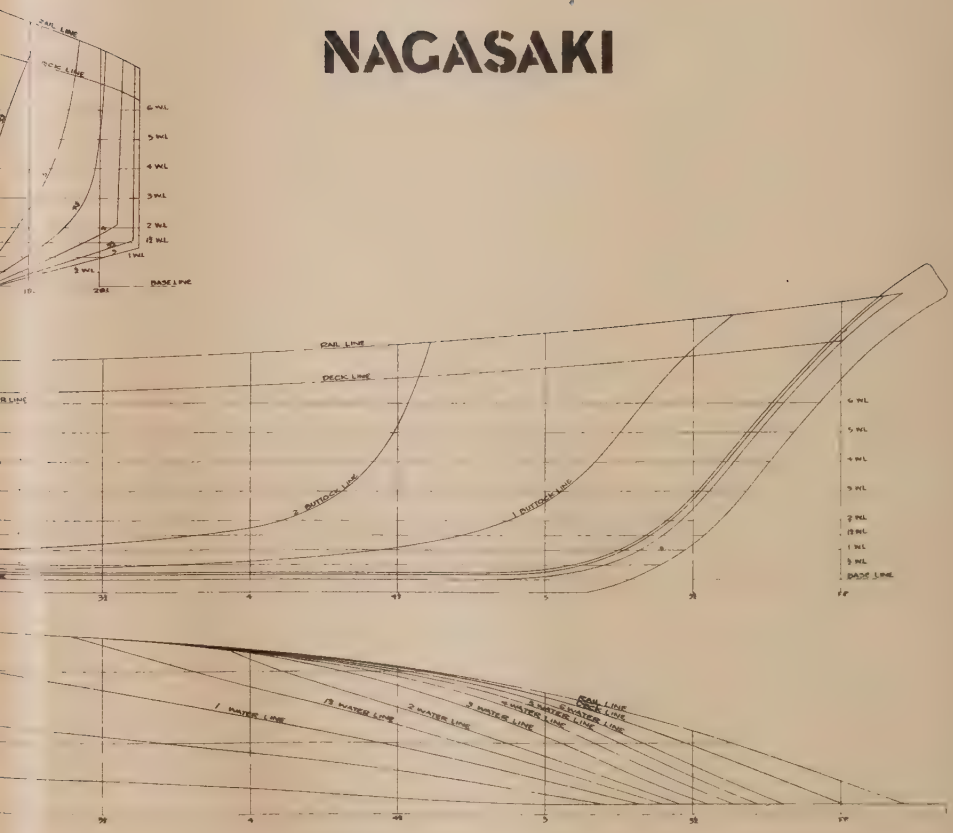
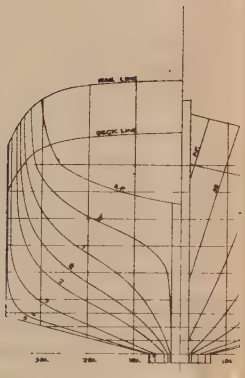
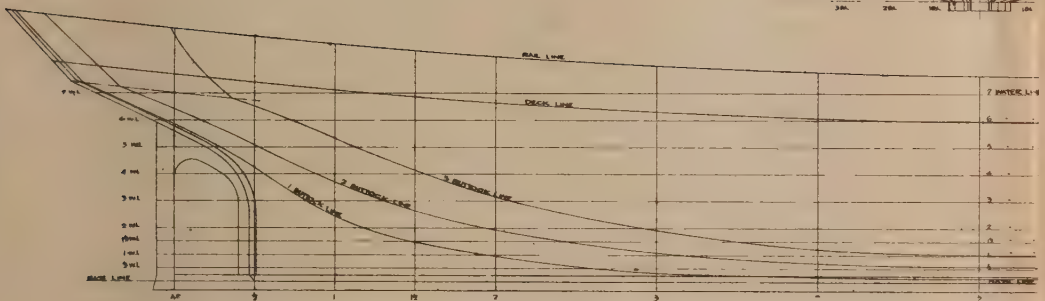

6 WATER LINE
5 WATER LINE
4 WATER LINE
3 WATER LINE
2 WATER LINE
1½ WATER LINE
1 WATER LINE
1 WATER LINE
2 BUTTOCK LINE
½ WATER LINE
1 BUTTOCK LINE
BASE LINE
RAIL LINE
DECK LINE
AP
0
½
1
1½
2
2½
3

Fig. 2.

NAGASAKI




RAIL LINE
DECK LINE


RAIL LINE
DECK LINE
1 BUTTOCK LINE
2 BUTTOCK LINE
3 BUTTOCK LINE
BASE LINE
MAIN LINE

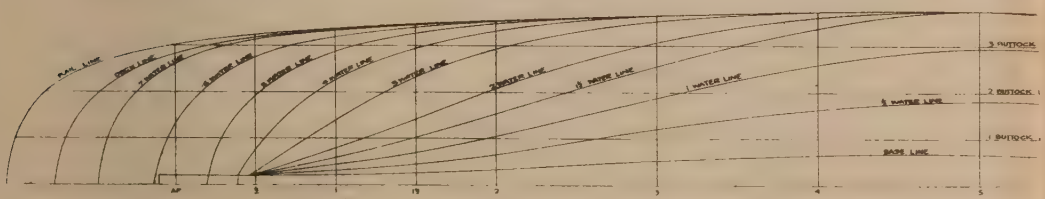
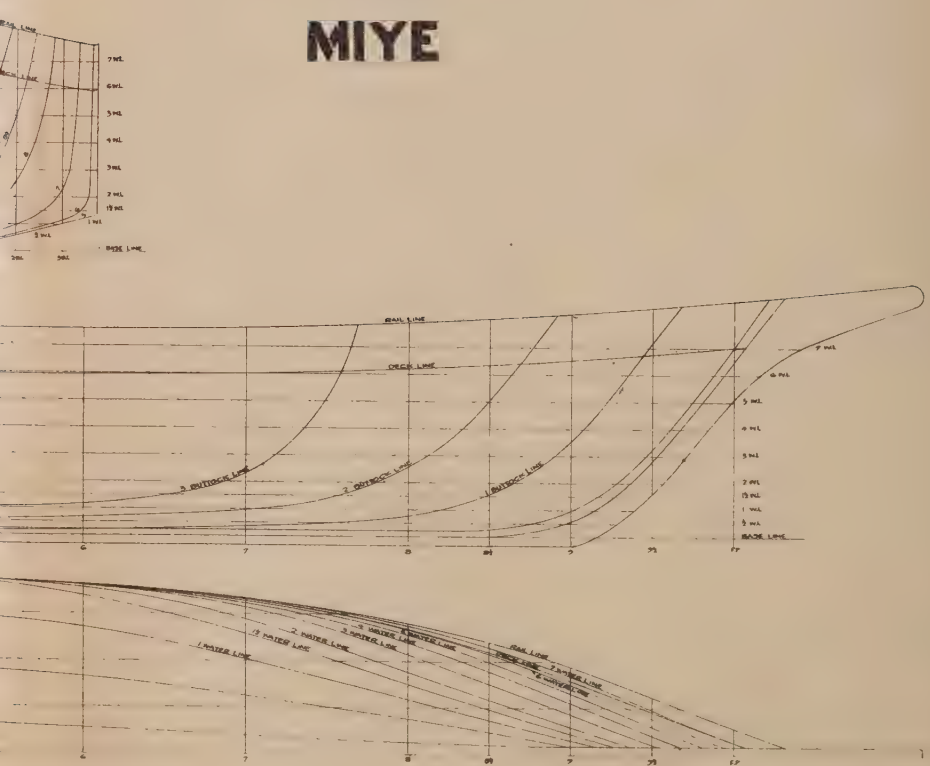

RAIL LINE
DECK LINE
1 WATER LINE
2 WATER LINE
3 WATER LINE
BASE LINE

Fig. 3.


RAIL LINE
DECK LINE
3 OUTSIDE LINE
2 OUTSIDE LINE
1 OUTSIDE LINE
BASE LINE
1 WATER LINE
2 WATER LINE
3 WATER LINE
4 WATER LINE
5 WATER LINE
6 WATER LINE

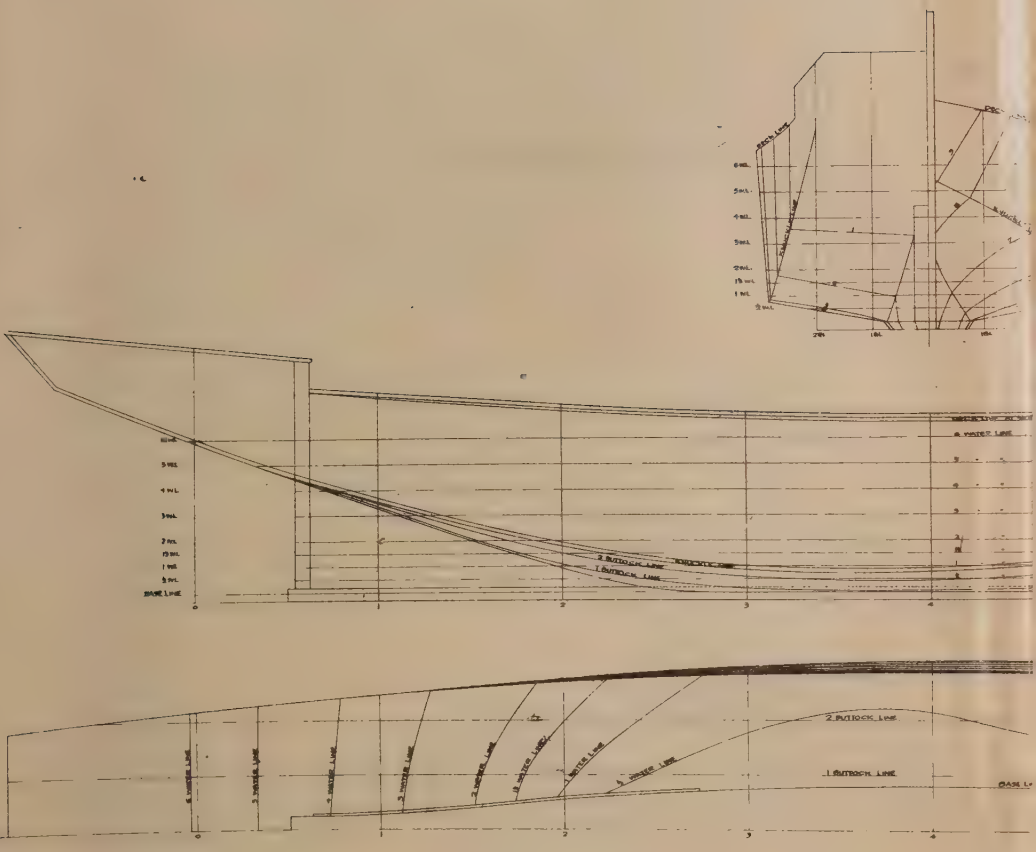
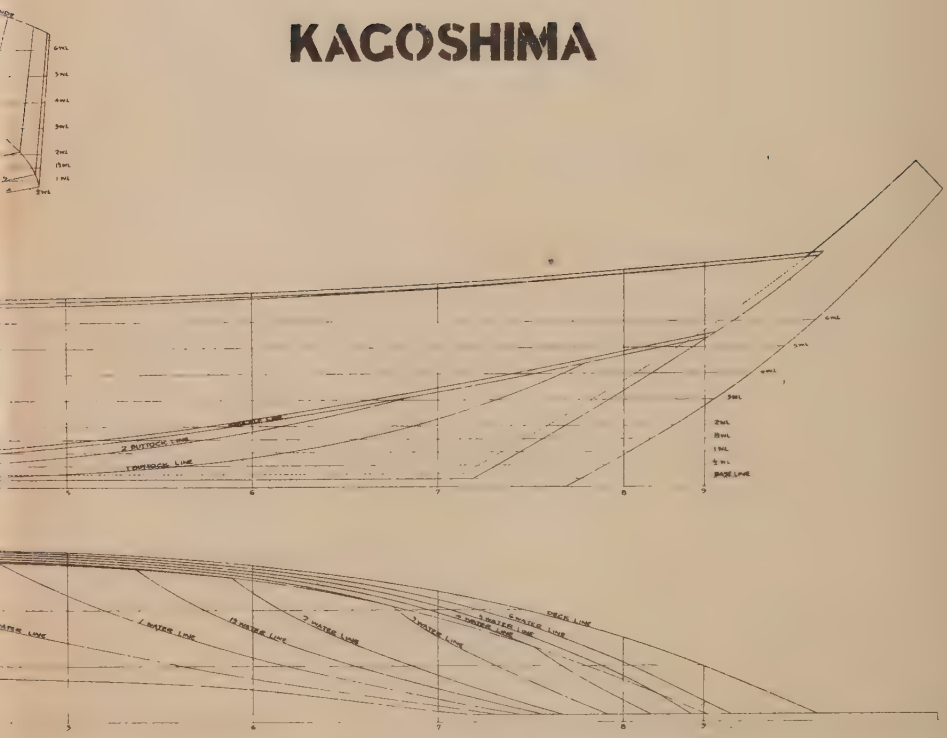
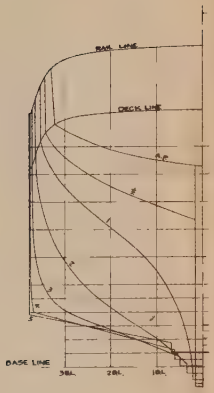
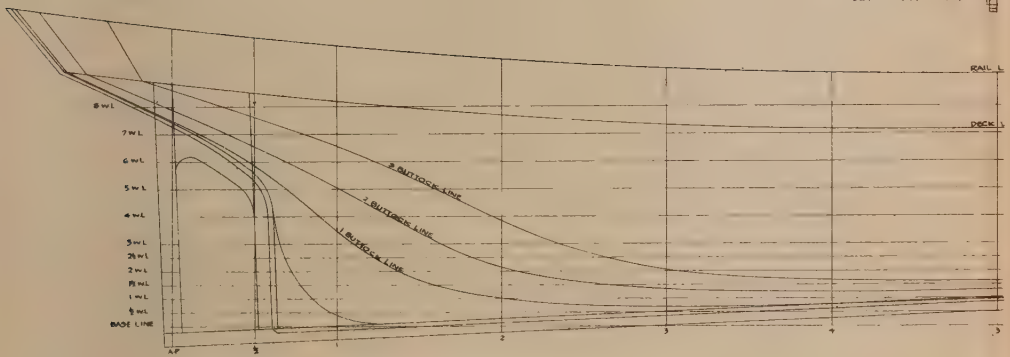

2 BUTTOCK LINE
1 BUTTOCK LINE
BASE LINE

Fig. 4.

KAGOSHIMA




RAIL LINE
DECK LINE
BASE LINE
3BL
2BL
1BL


RAIL L
DECK L
8 WL
7 WL
6 WL
5 WL
4 WL
3 WL
2½ WL
2 WL
1½ WL
1 WL
½ WL
BASE LINE
3 BUTTOCK LINE
2 BUTTOCK LINE
1 BUTTOCK LINE
AP

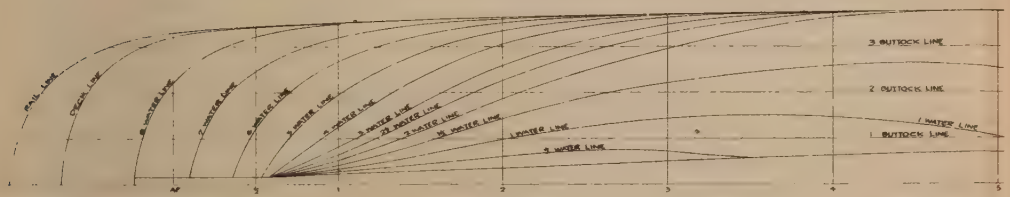

RAIL LINE
DECK LINE
3 BUTTOCK LINE
2 BUTTOCK LINE
1 BUTTOCK LINE
AP

Fig. 5.

WAKAYAMA

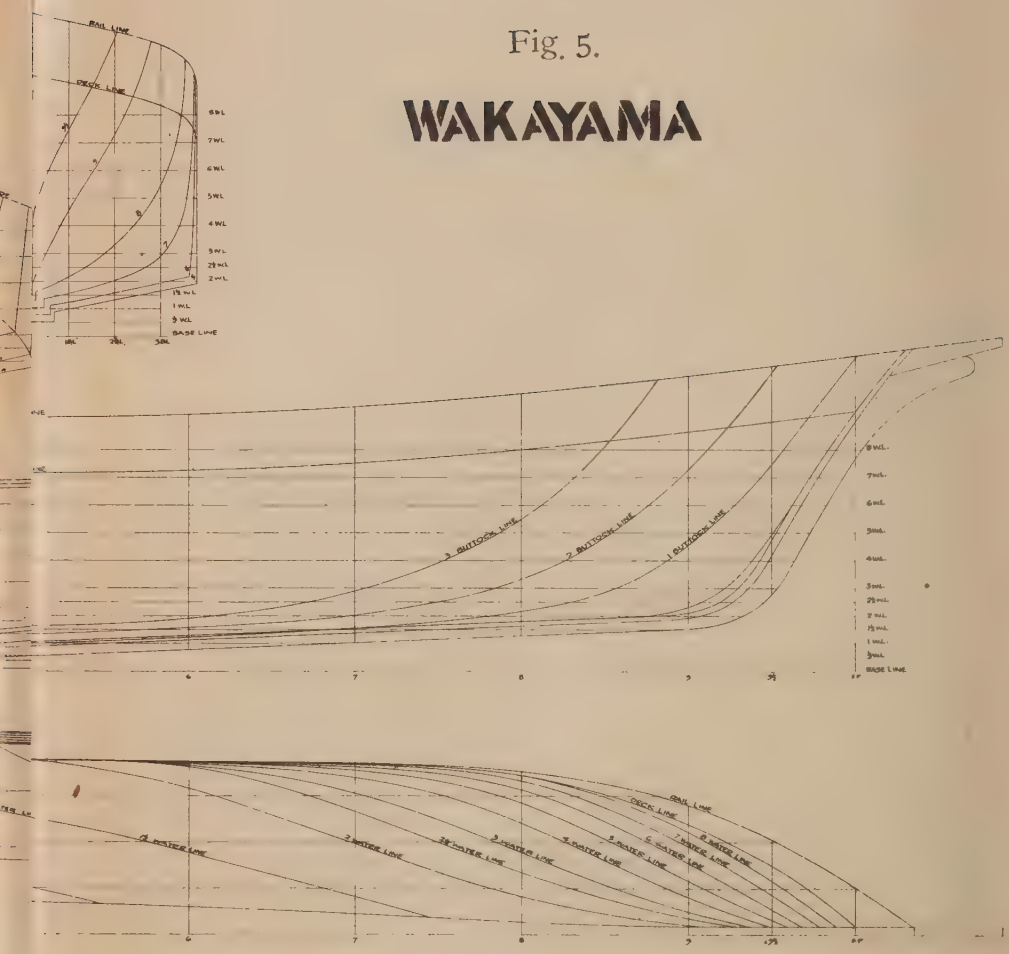


Fig. 11.

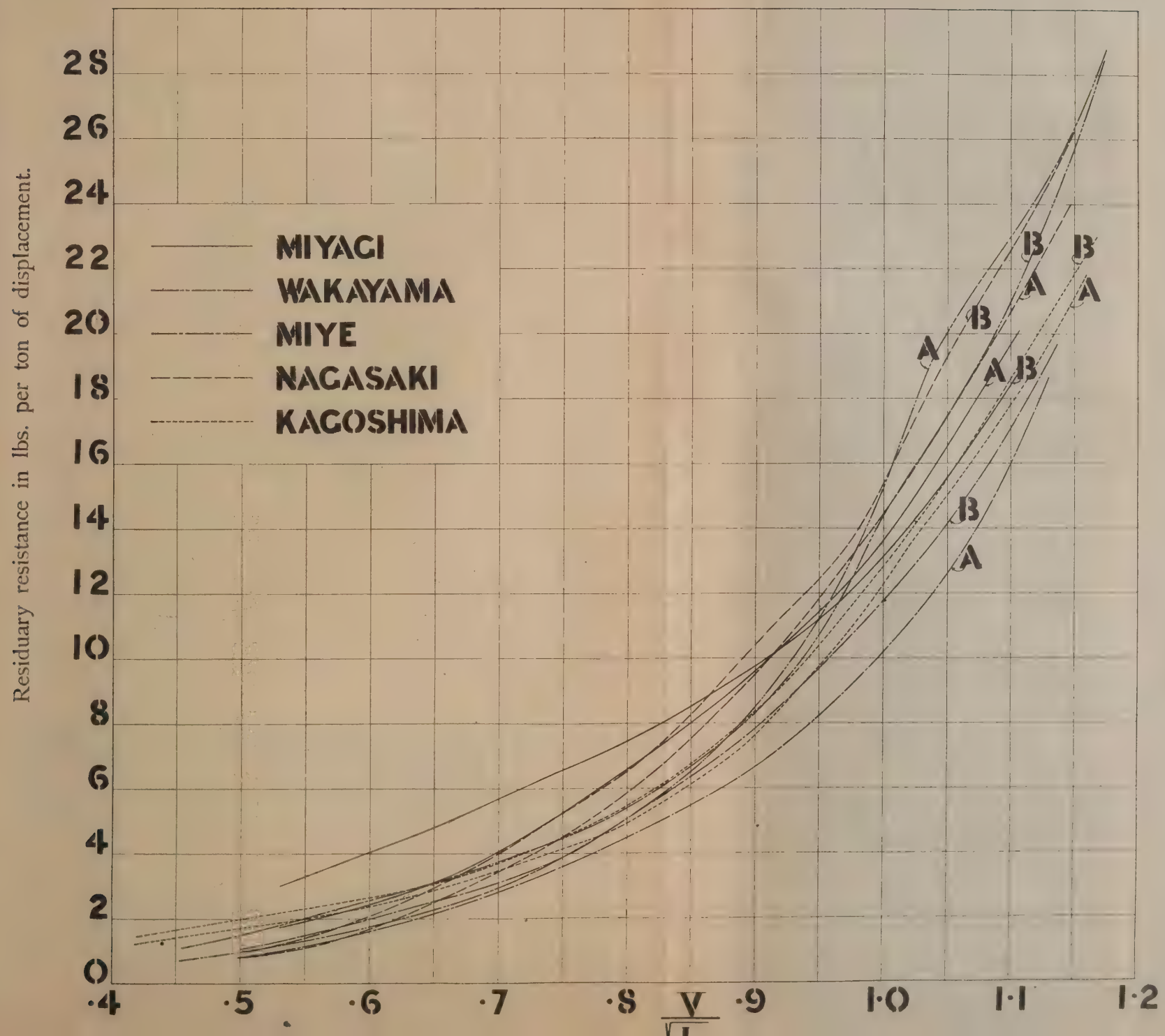
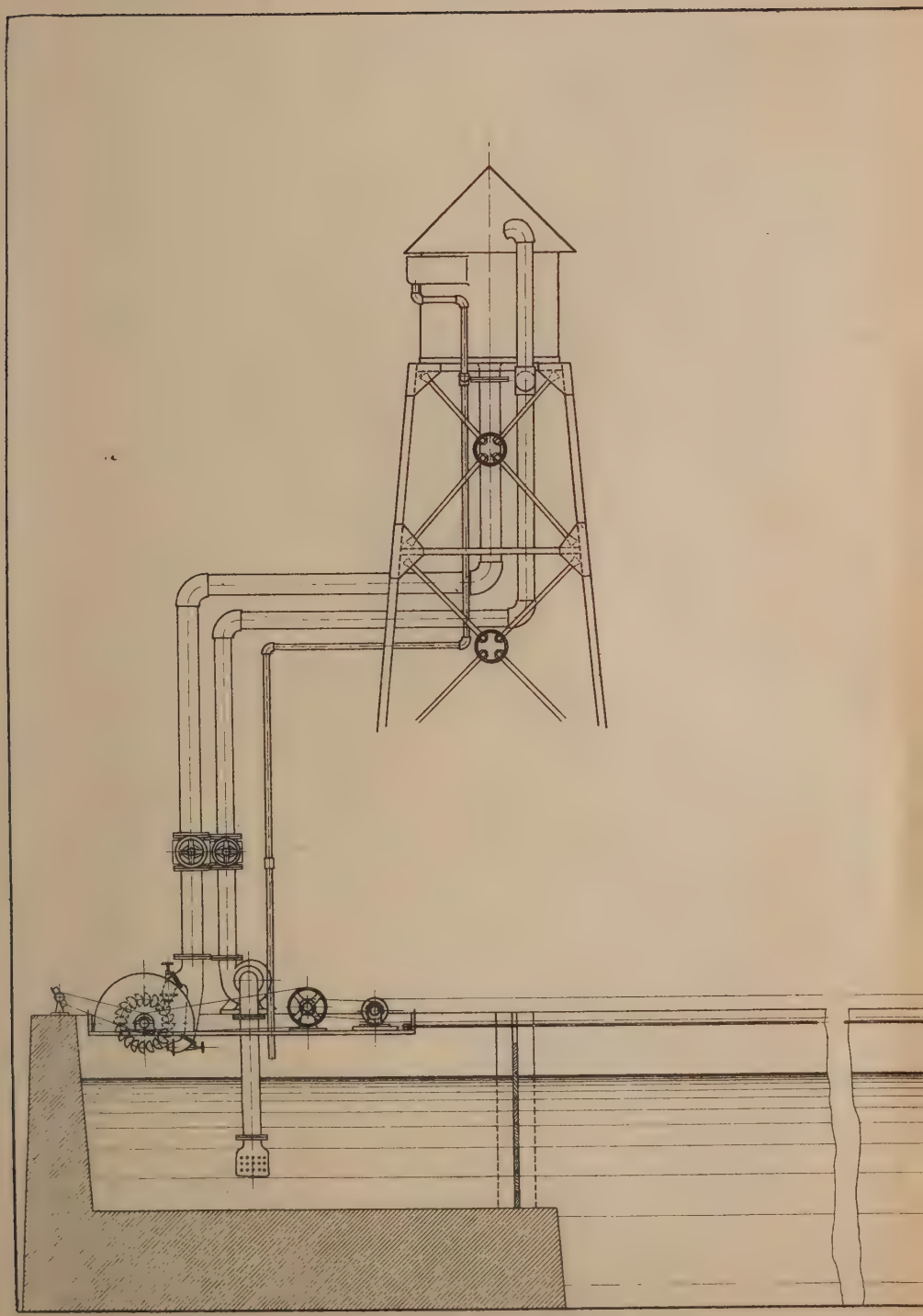

Residuary resistance in lbs. per ton of displacement.
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
MIYAGI
WAKAYAMA
MIYE
NAGASAKI
KAGOSHIMA
A
B
·4
·5
·6
·7
·8
·9
1·0
1·1
1·2
V/√L

Fig. 17.



General Arrangement.

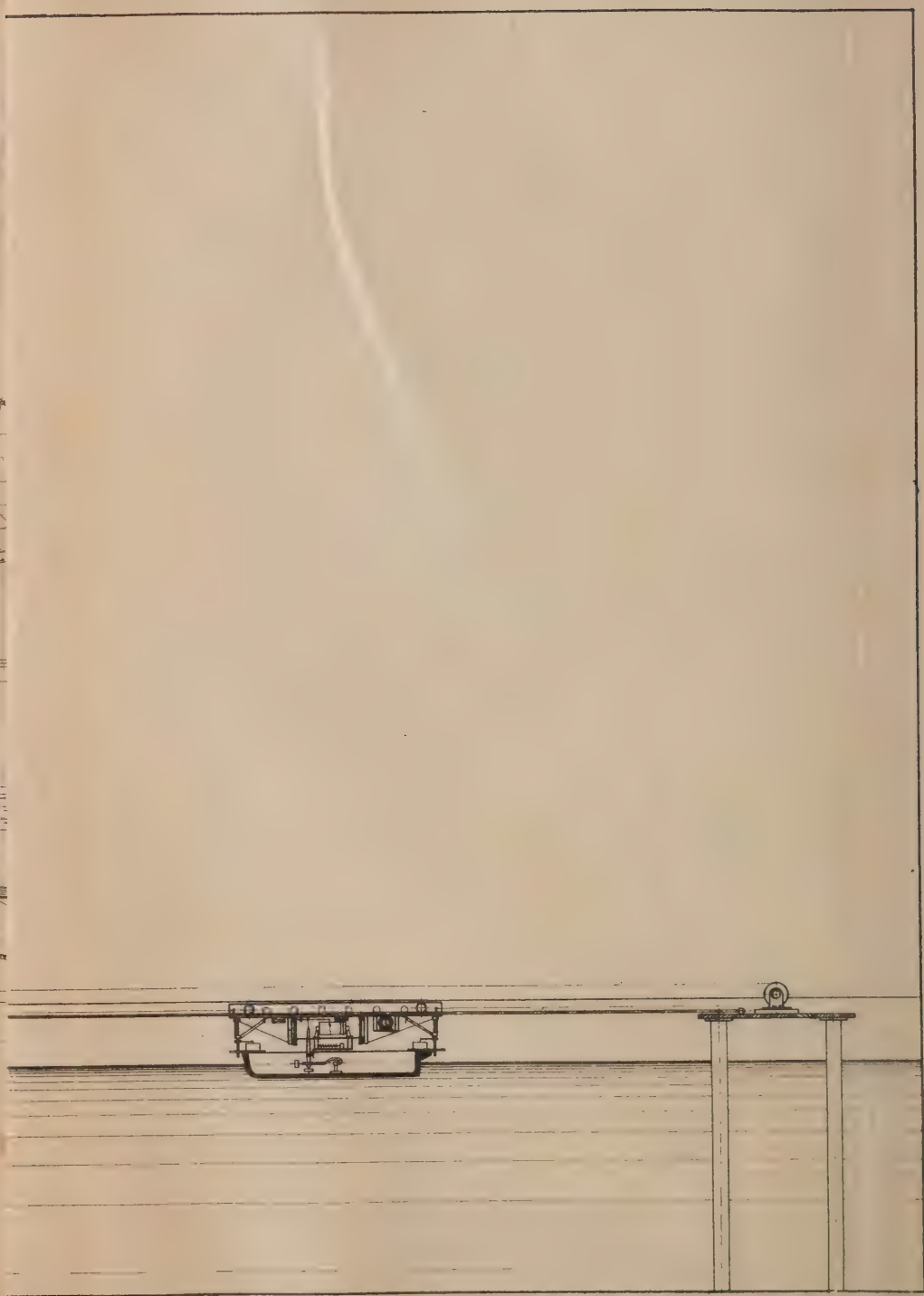
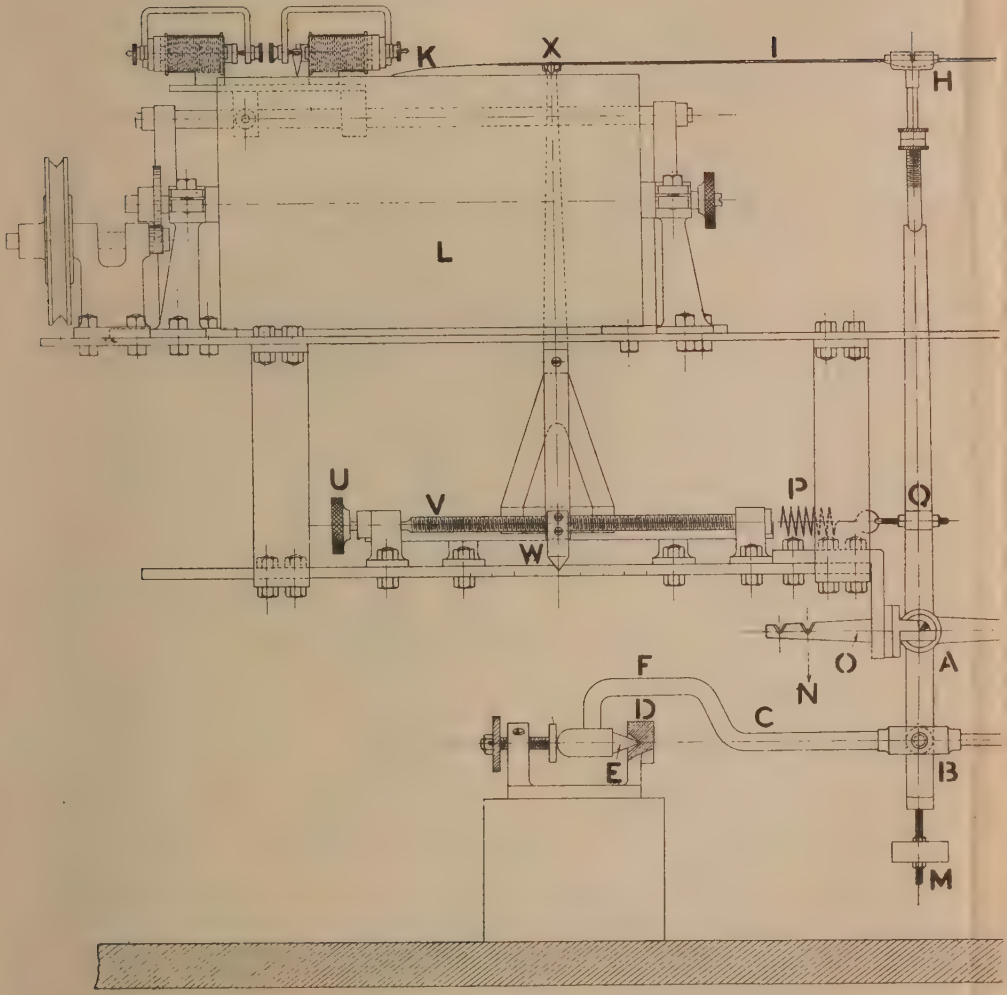


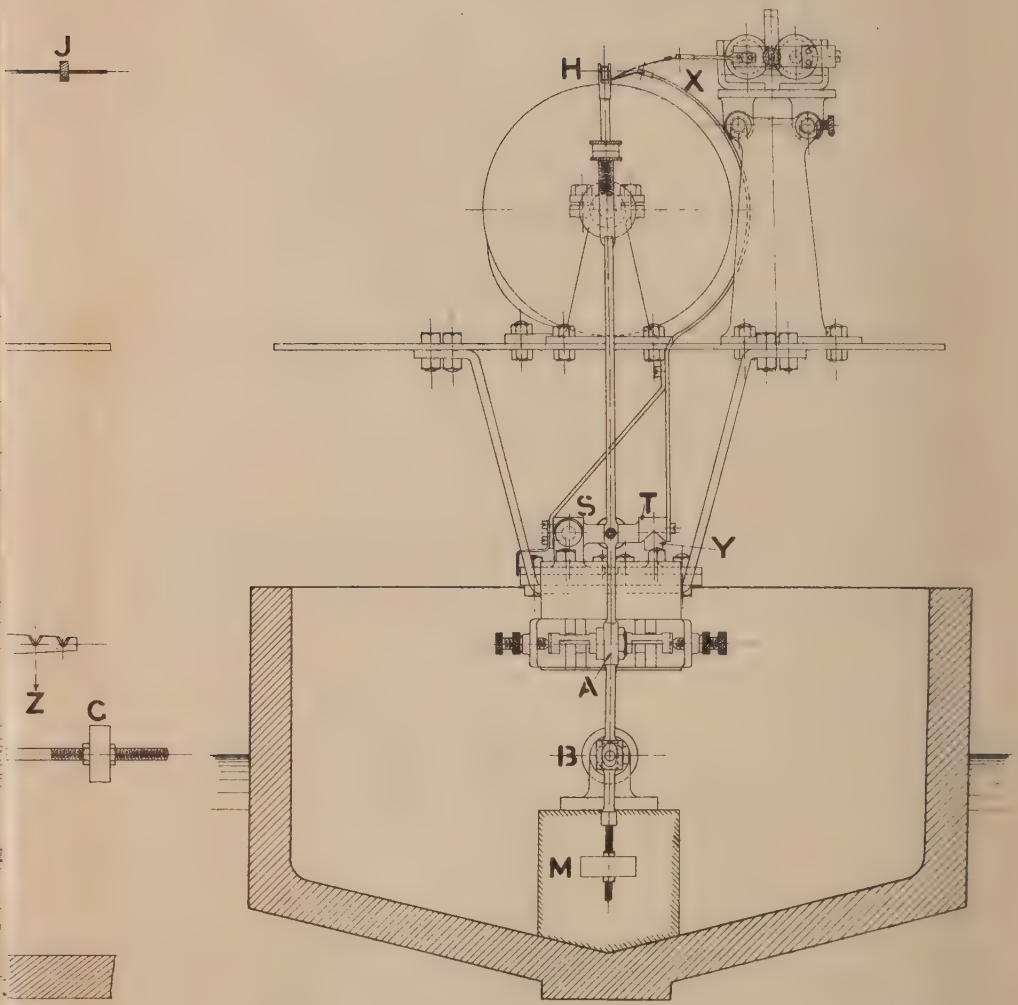
Fig. 18.

FRONT ELEVATION
(FULL SIZE)



DYNAM

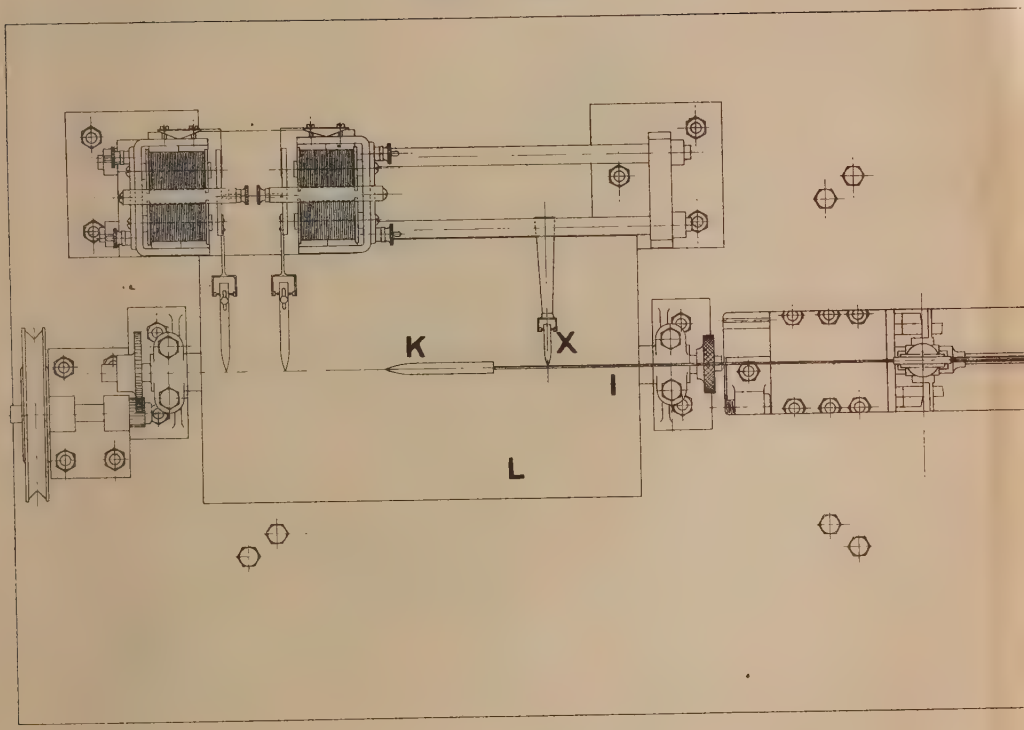
SIDE VIEW
(FULL SIZE)



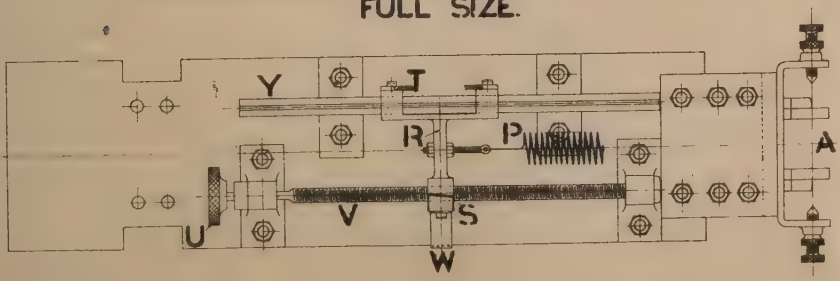
OMETER

Fig. 19.

PLAN.
FULL SIZE.



BASE LINE SHIFTER (PLAN)
FULL SIZE.



END VIEW.

FULL SIZE.

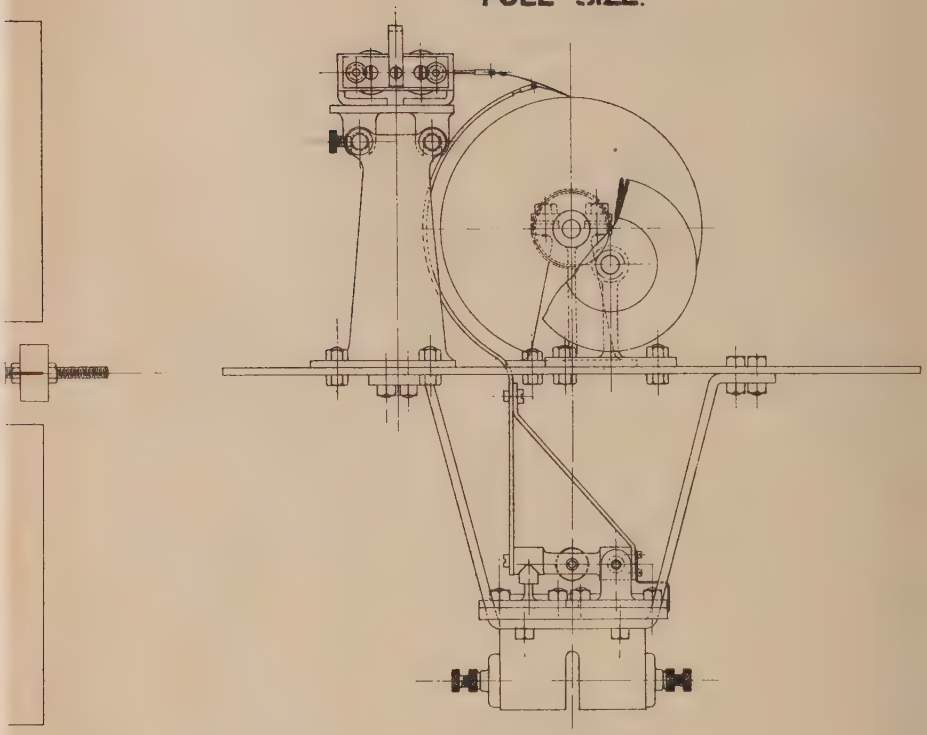
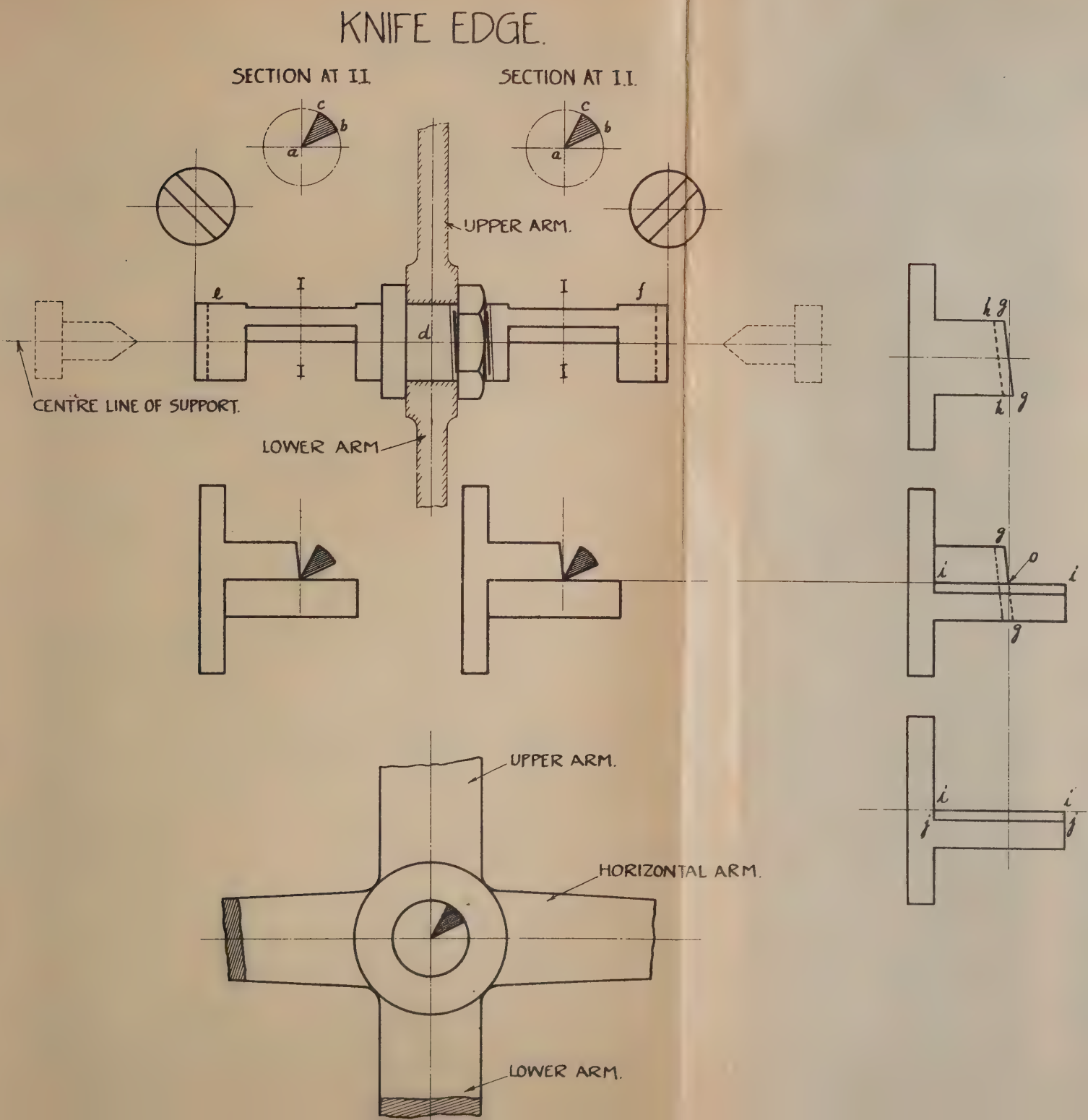
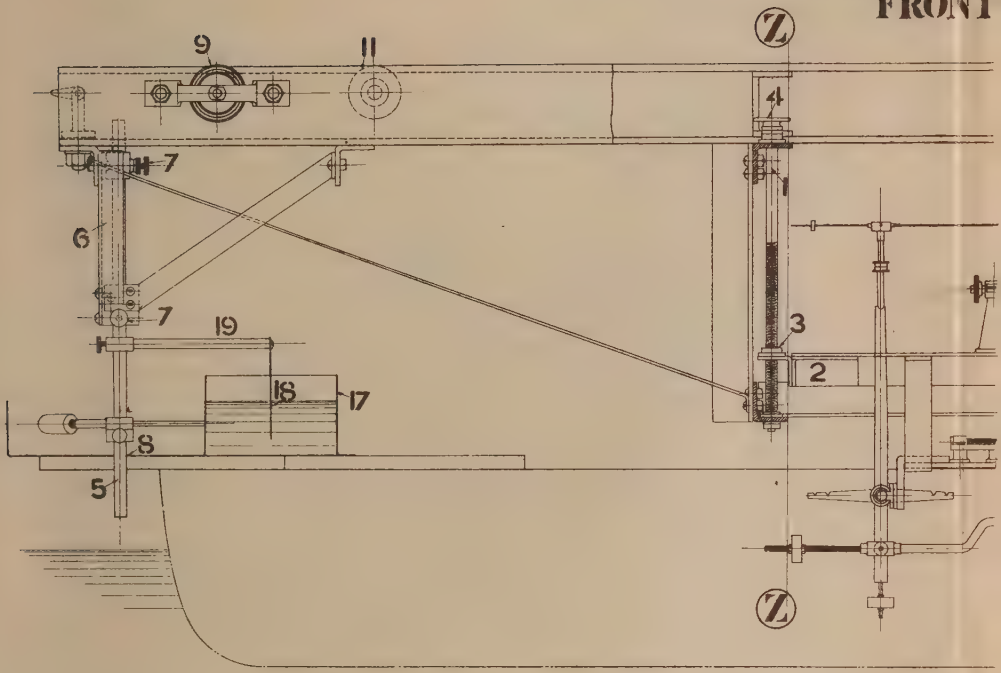


Fig. 20.


KNIFE EDGE.
SECTION AT II.
SECTION AT I.I.
c
b
a
UPPER ARM.
e
I
I
d
I
I
f
CENTRE LINE OF SUPPORT.
LOWER ARM
h g
h
g
g
i
o
i
g
i
i
f
f
UPPER ARM.
HORIZONTAL ARM.
LOWER ARM.

TRUCK &

FRONT



PLA

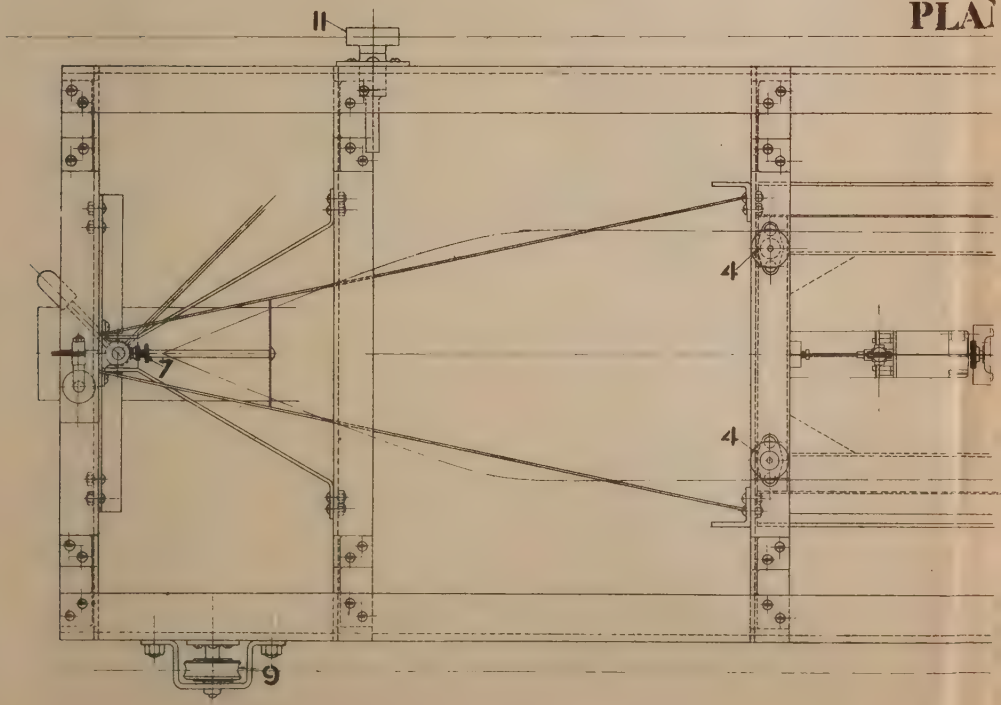
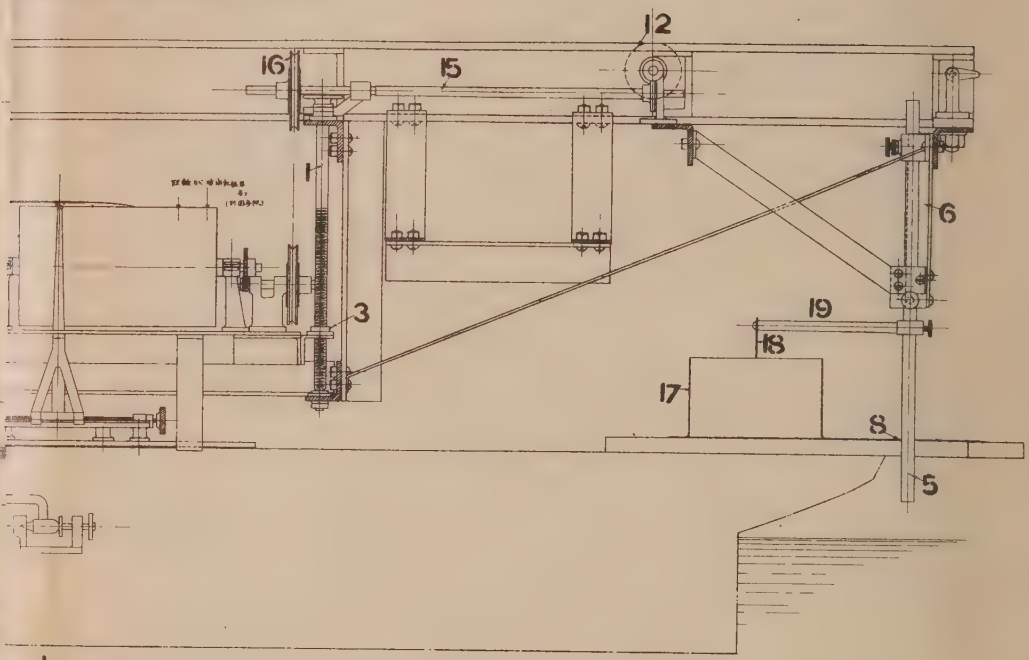


Fig. 21.

DYNAMOMETER

ELEVATION ½ SIZE



½ SIZE

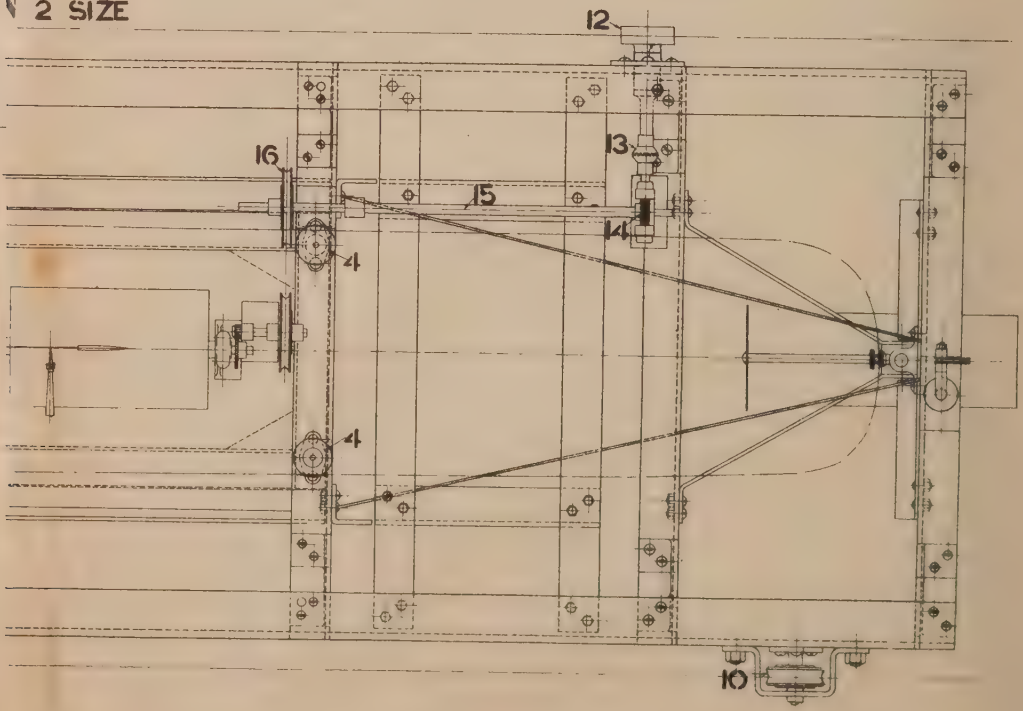
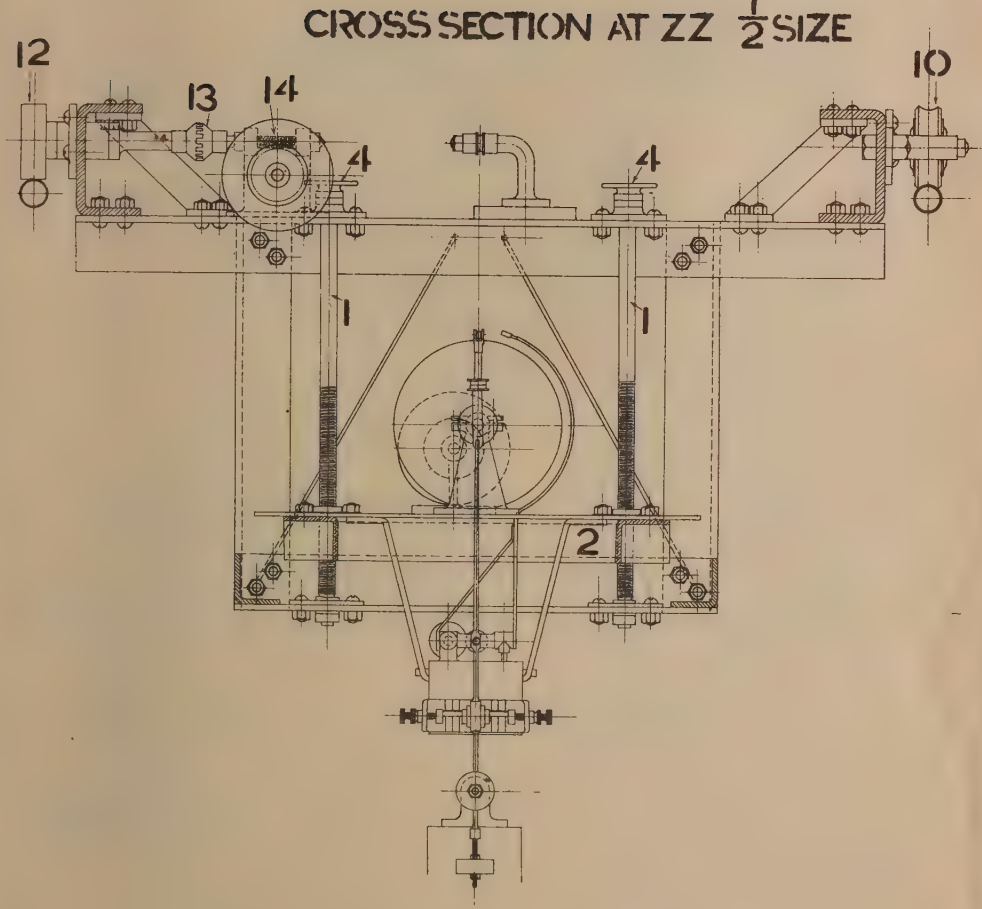


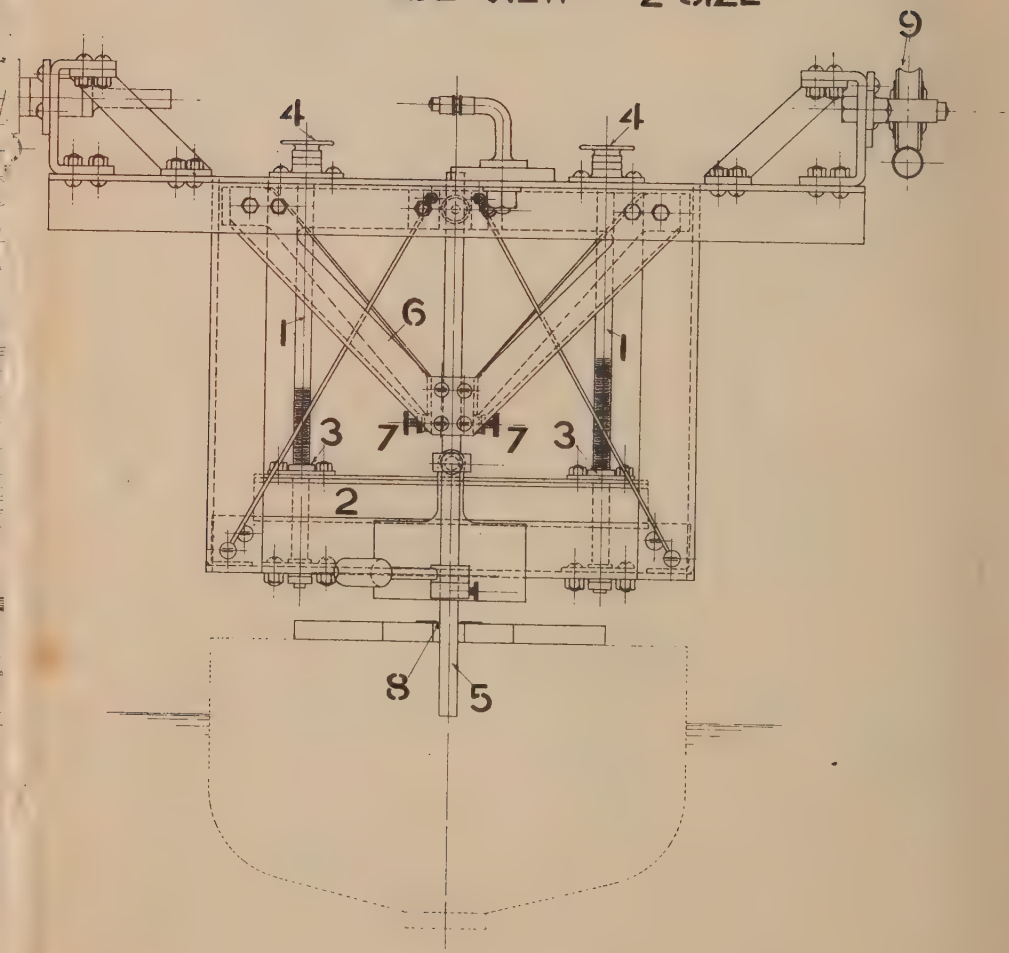
Fig. 2

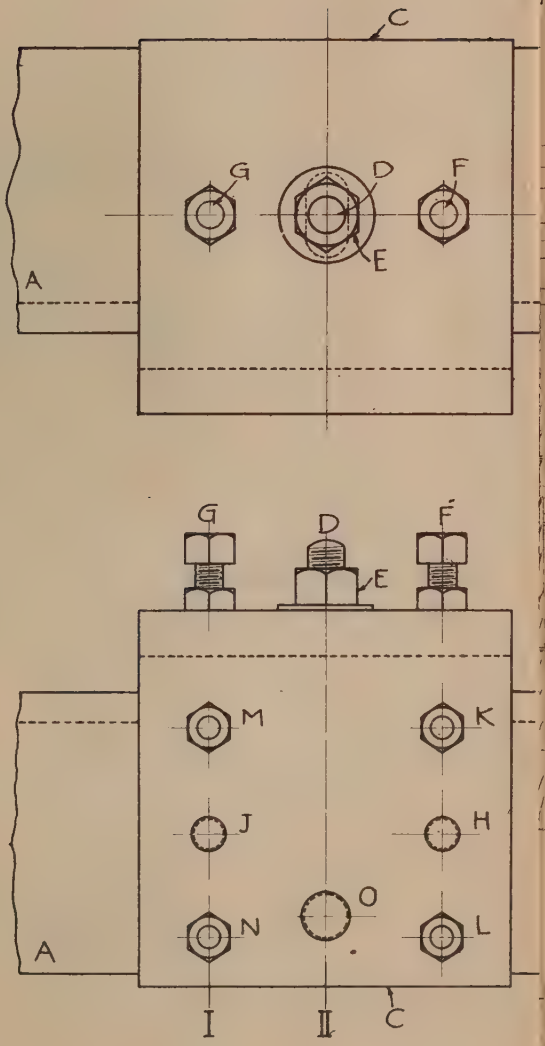
TRUCK & DYN

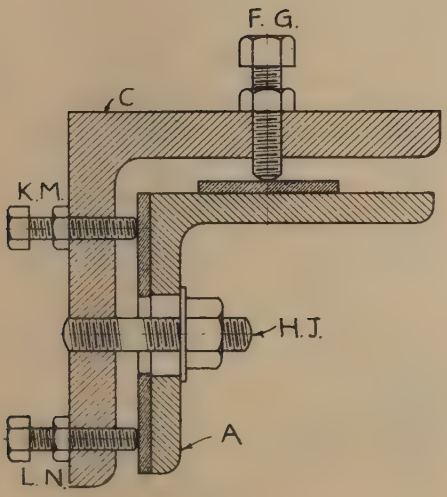


NAMOMETER

SIDE VIEW $\frac{1}{2}$ SIZE

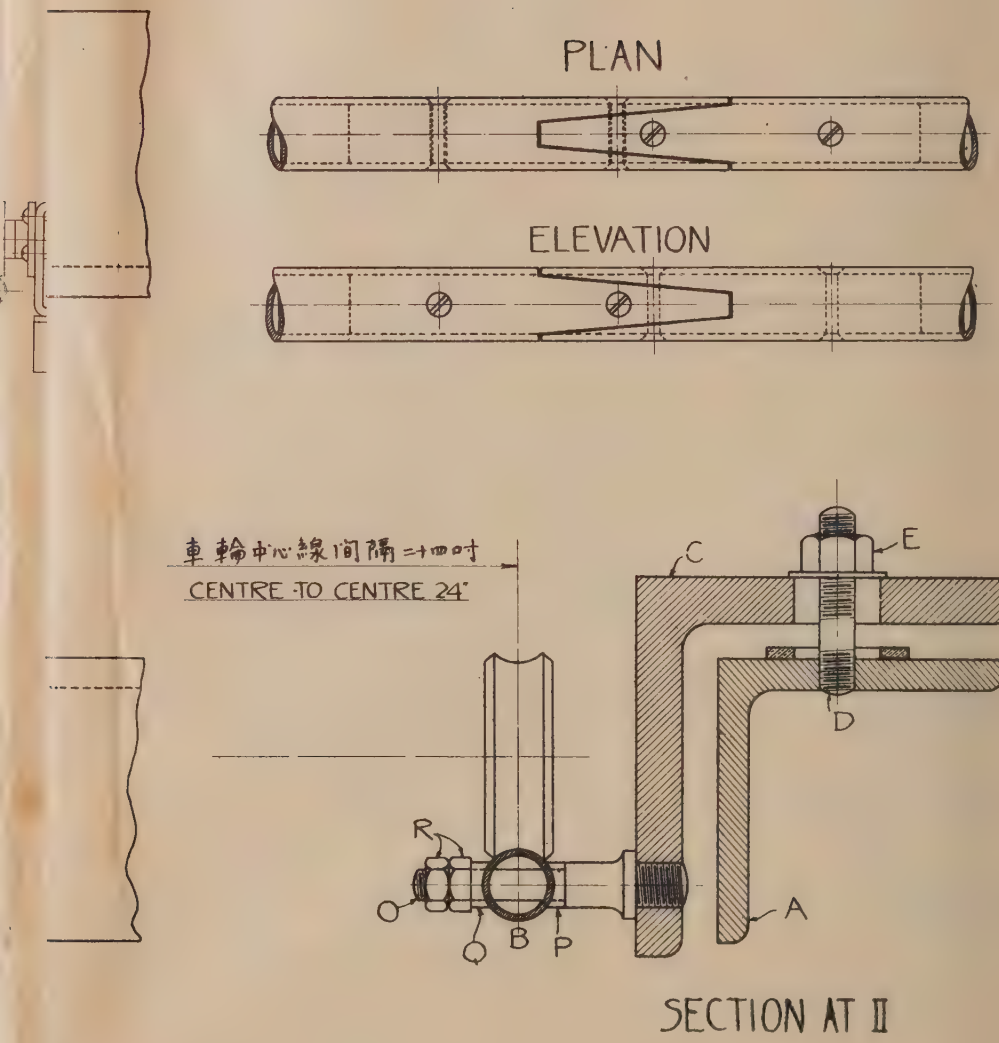






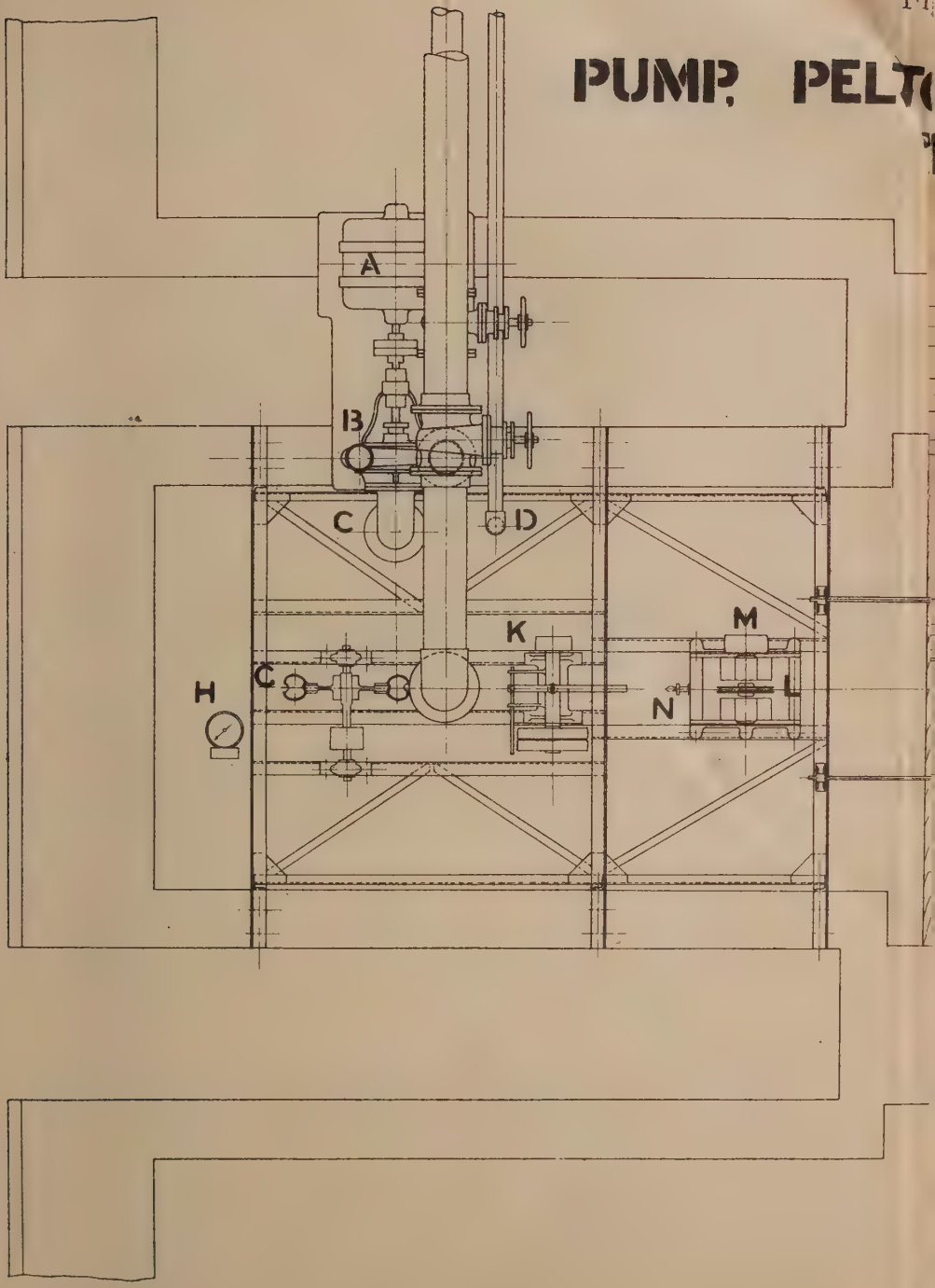
SECTION AT I

Fig. 23.


PLAN
ELEVATION
車輪中心線間隔二十四吋
CENTRE TO CENTRE 24"
C
E
D
A
R
Q
B
P
SECTION AT II

Fi

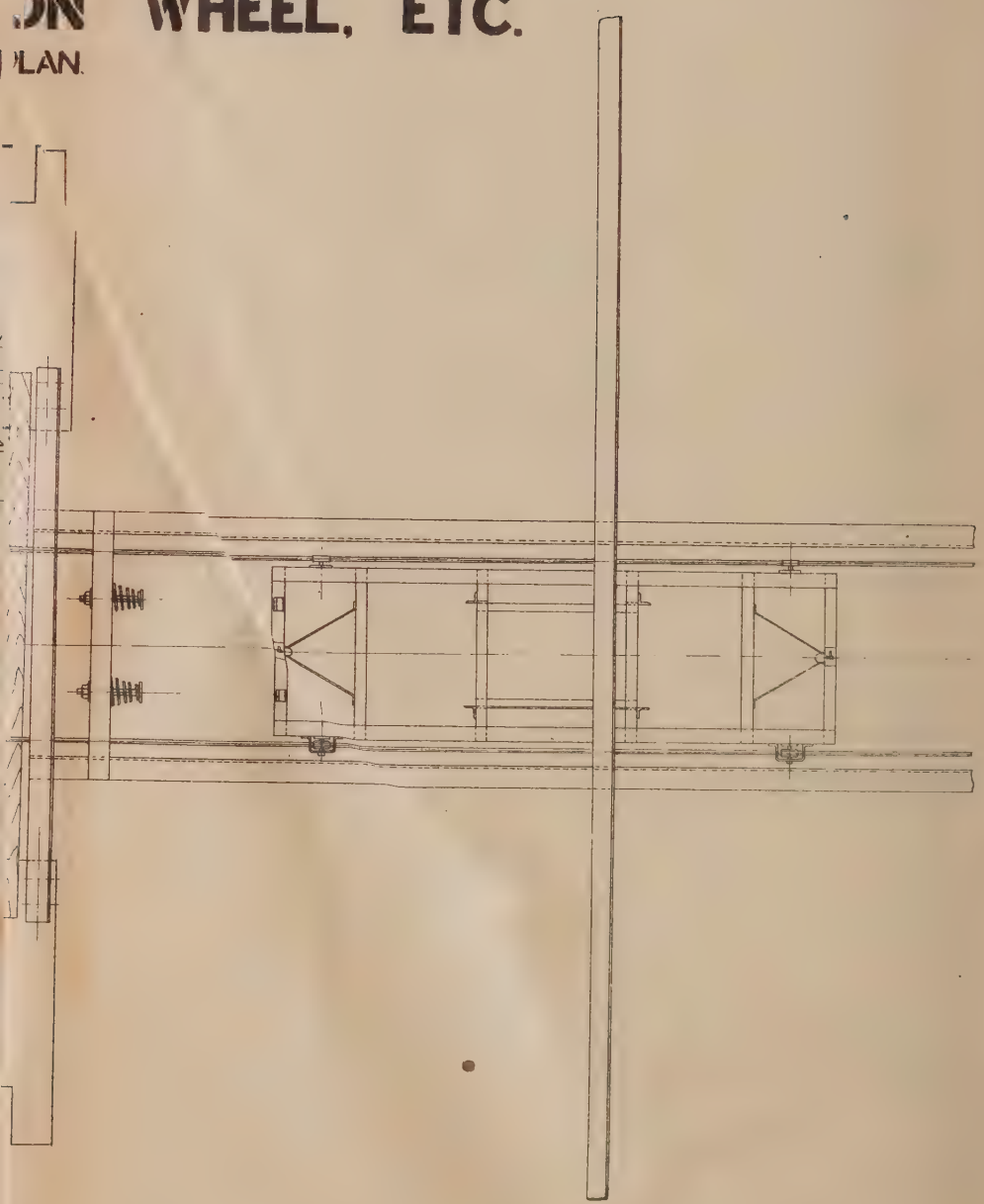
PUMP, PELT



g. 25.

ON WHEEL, ETC.

PLAN.



PUMP, PEL

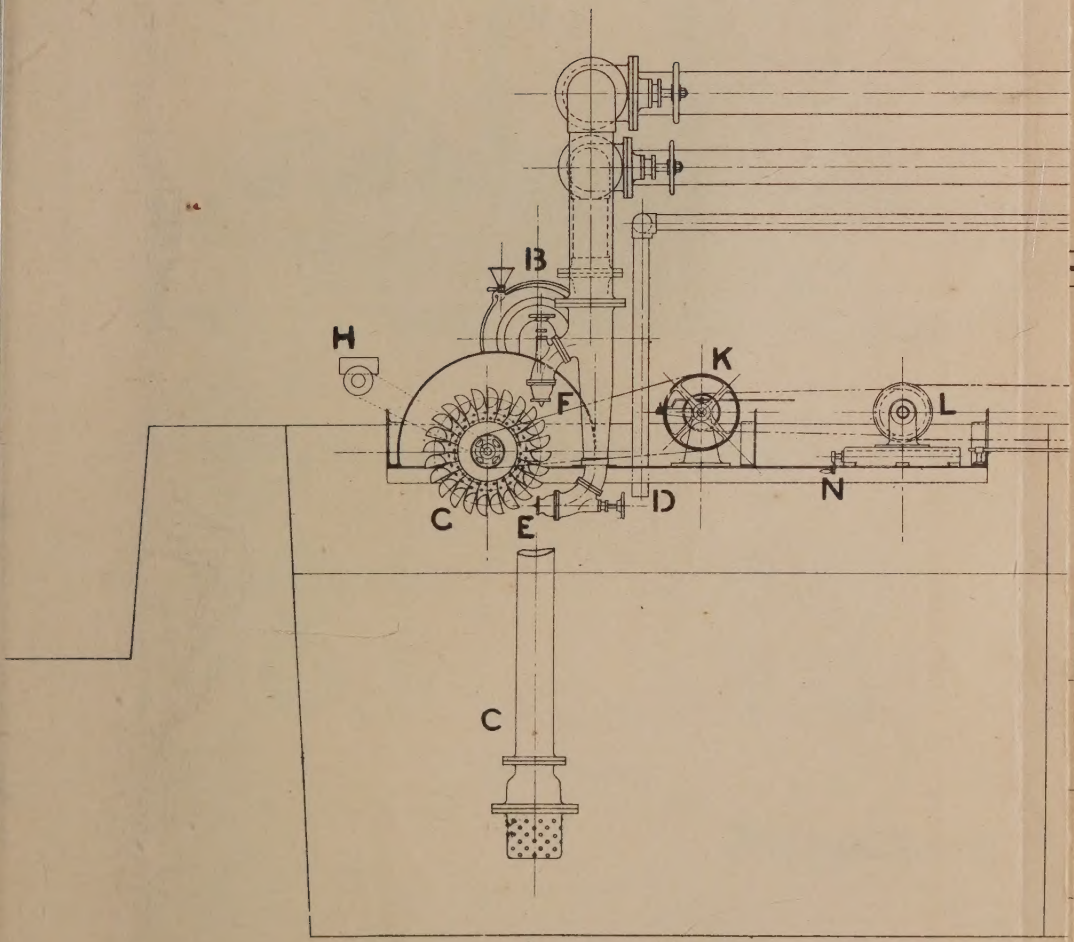
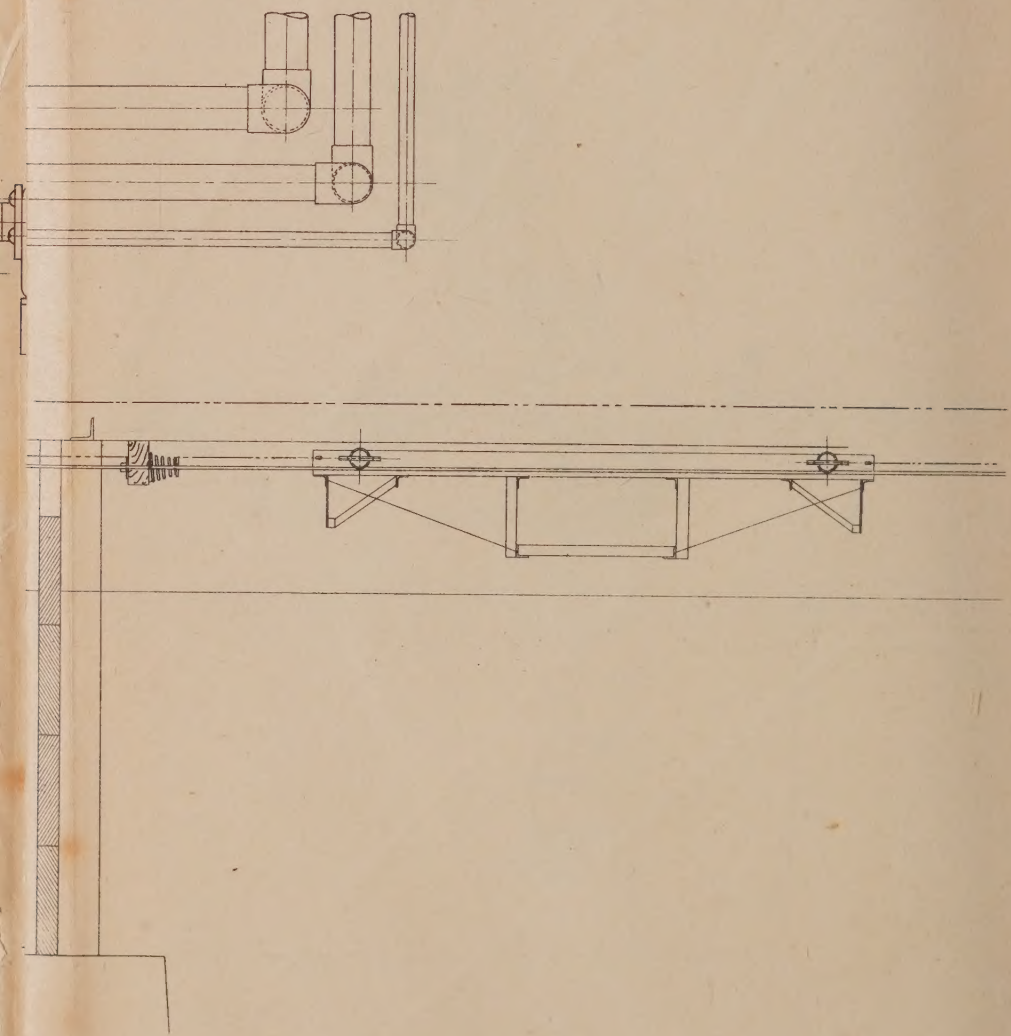
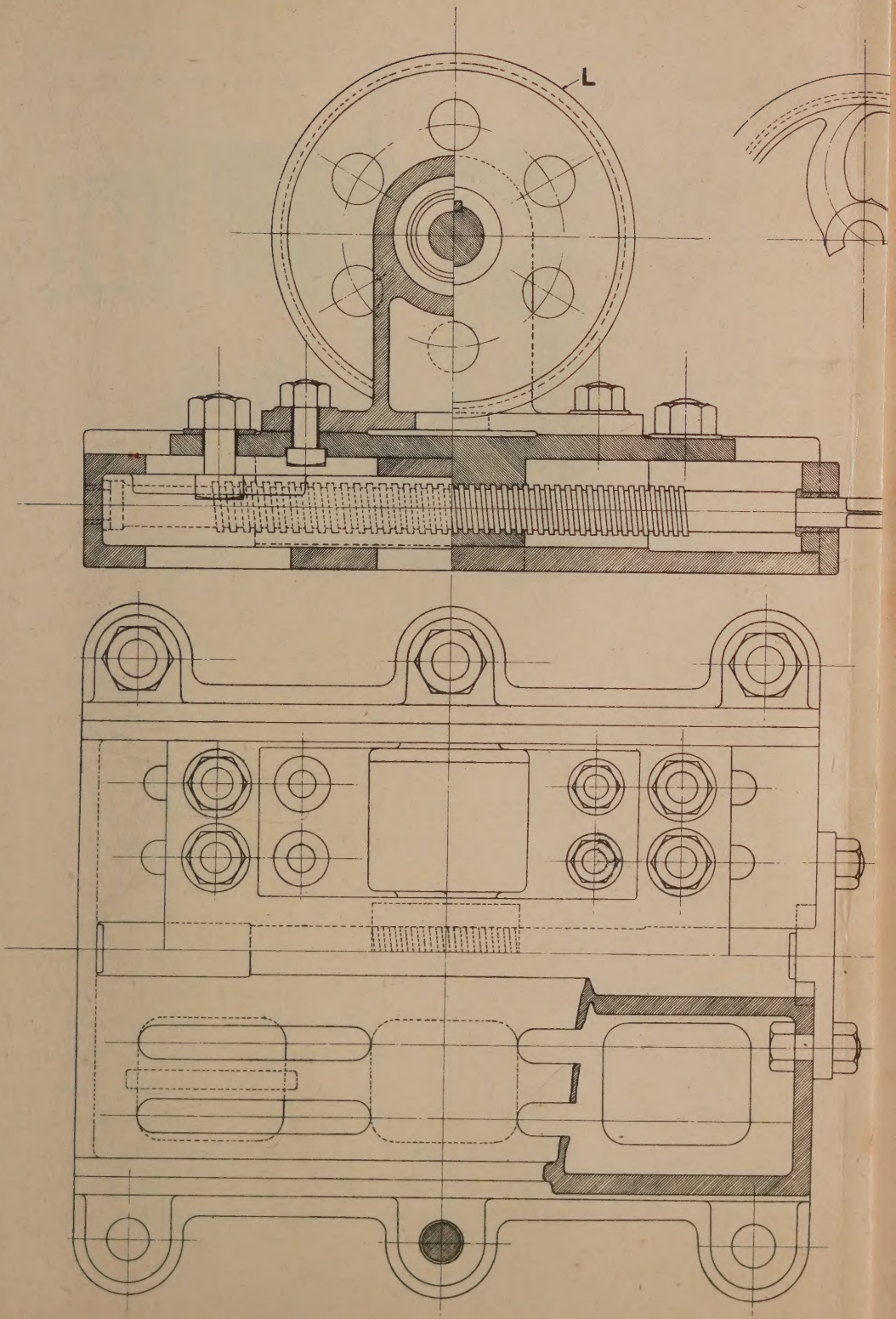


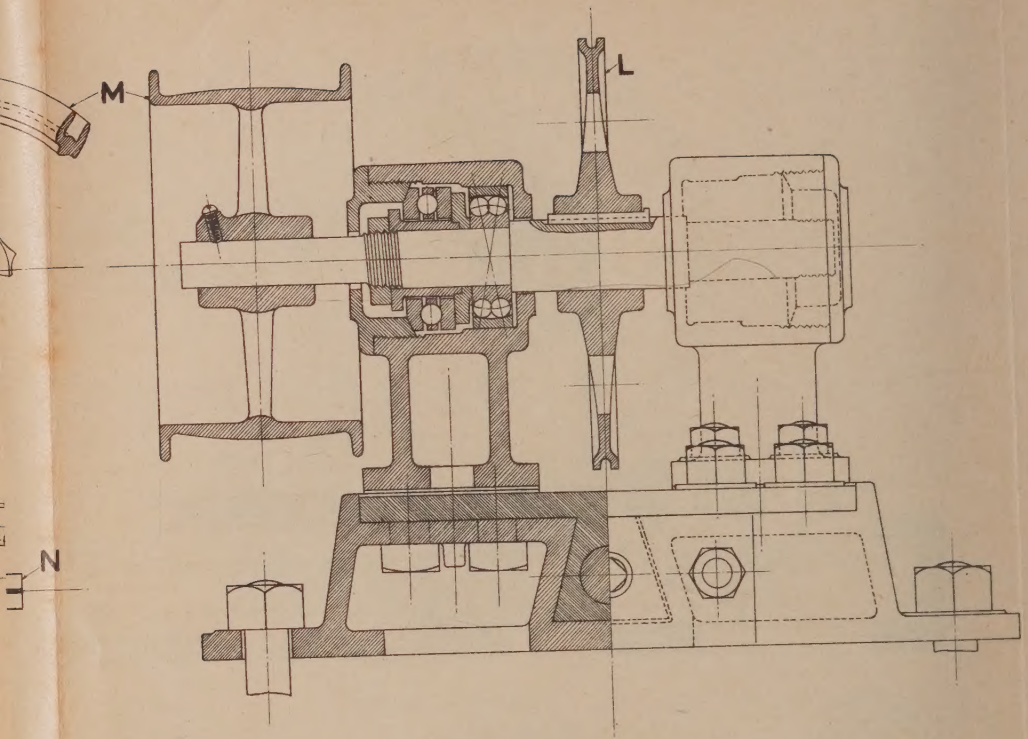
Fig. 26.

LTON WHEEL, ETC.

SIDE ELEVATION.




L


M
L
N